Learning to use melodic similarity and contrast for narrative using a Digital Tabletop Musical Interface

Thesis

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Learning to use melodic similarity and contrast for narrative using a Digital Tabletop Musical Interface

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List of Acronyms

CSCL	Computer-Supported Collaborative Learning
CSCM	Computer-Supported Collaborative Music
CSCW	Computer-Supported Collaborative Work
DTI	Digital Tabletop Interface
DTMI	Digital Tabletop Musical Instrument/Interface
GCSE	General Certificate of Secondary Education
GUI	Graphical User Interface
HCI	Human-Computer Interaction
HREC	Human Research Ethical Committee
MIDI	Musical Instrument Digital Interface
OSC	Open Sound Control
TUI	Tangible User Interface
TUIO	Tangible User Interface Objects
WIMP	Windows, Icons, Menus, Pointer

Abstract

This thesis investigates Digital Tabletop Musical Interfaces (DTMIs) in the context of music education. Digital tabletops have emerged in recent years, surrounded by much enthusiasm, and have found applications in a diversity of fields – from museum installations to engineering applications, from information systems, to music making. In particular, their ability to create a link between the physical and virtual world makes the digital tabletop an excellent way for beginners to approach music making. By allowing users to "touch" music, and experience it through various visual representations, in addition to its aural representation, digital tabletops provide an intuitively approachable way of making music that supports both beginners and experts, and allows them to collaborate and exchange knowledge and ideas. However, we still know little about the challenges and opportunities that DTMIs present, particularly their role in supporting music education.

This thesis explores the challenges and opportunities presented by a bespoke DTMI in supporting people of different levels of musical experience in learning about some fundamental musical notions, and in learning how these can be used to compose music in an intentional way. This thesis covers three exploratory studies. In the first one, the notion of melodic contour, and its role as a visual metaphor for describing music, were explored by participants. A music composition task to describe a painting with music was presented to participants, and the ways in which participants described and composed music, in relation to melodic contour, were analysed. In the second study, the notions of melodic similarity and contrast, and their role in suggesting narrative, were explored by participants. Through a series of discussions and practical exercises, participants developed their understanding of melodic similarity and contrast, and learned how to use these notions to suggest narrative in melody. The third study followed directly from the second one, exploring again melodic similarity and contrast, but this time in a group setting. Groups of participants explored the musical notions using the DTMI as a discussion mediator. In these last two studies, the ways in which participants discussed the notions, and used them to compose music that suggested a narrative, were analysed.

The findings suggest that it is possible to appropriately design a DTMI that can be used by both musically experienced and inexperienced people in order to create music in a way that is graspable for the novice, yet expressive for the expert, so that the two can discuss music with equal ease, and learn more about it.

Preface

The work presented in this thesis has led to the following publications, in chronological order.

1. Franceschini, A., Laney, R. and Dobbyn, C. (2013). "A study of contour in music using digital tabletop musical instruments". In *Digital Music Research Network (DMRN+8)*, London, UK.
2. Franceschini, A., Laney, R. and Dobbyn, C. (2014). "Learning Musical Contour on a Tabletop". In *Proceedings of the Joint International Computer Music Conference and Sound and Music Computing Conference (ICMC-SMC), Athens, Greece.*

The two publications are based on the contents of chapter 4. The first publication was presented as a poster, and describes the design of Study 2, and preliminary results. The second publication was included in the proceedings and presented as a poster. It describes the design of Study 2, and preliminary results from the qualitative analysis presented in this thesis.

The design of the studies presented in this thesis were examined by the OU Human Research Ethics Committee, and approved as follows:

- Pilot study (chapter 3) with reference number HREC/2012/1318/Franceschini/1.
- Study 1 (chapter 4) with reference number 65064.
- Study 2 (chapter 5) with reference number HREC/2014/1797/Franceschini/1.
- Study 3 (chapter 6) with reference number HREC/2014/1867/Franceschini/1.

1 Introduction

Music is complicated. Western music, and classical music in particular, is often perceived by the uninitiated as difficult to understand and engage with. It does not help that music is an inherently abstract and intangible phenomenon that arguably only exists in the mind of the listener (Wiggins et al., 2010). It also does not help that the way in which music is traditionally taught is by focussing on tirelessly practising instrumental and performance technique, and engaging in the study of the history of music (Xambó, 2015). Add to this the study of the theory of music, an ever growing corpus of prescriptions that can appear intimidating and puzzling, and engaging in music studies becomes daunting. It is easy to imagine how novice music students, who may not be highly motivated from the beginning, would prefer to spend their time in more easily accessible, and immediately rewarding activities. In general, there is no obligation to study and play music, and yet it is often an activity that many people engage in, and enjoy. In fact, there are good reasons for learning how music is discussed and composed, as this can provide one with some of the tools for becoming a more active and proficient listener, and perhaps a musician as well.

This thesis explores the role of digital tabletop technology in music education. In particular, it investigates whether, and how, digital tabletop technology can assist novices in the early stages of learning, by providing them with the tools for discussing and making music, while learning certain fundamental concepts of music theory. The use of digital technologies aimed at improving education has been researched widely over the past few decades – in particular, Malone (1980) presents several suggestions for the improvement of educational video games, and Denis2004 argue in favour of video games for music education –

and research on digital tabletops aimed at education started to appear recently (Dillenbourg et al., 2011). It is arguable that digital tabletop technology has the necessary qualities to support the development of valuable educational support tools. However, rigorous empirical research in this field has only recently started to appear (Marshall, 2007), and systematic research is still sparse.

At the turn of the millennium, Taylor et al. (2000) noted that music teachers mostly used technology to do administrative tasks, as opposed to integrating it into their teaching. The cost of equipment, as well as the time necessary to train teachers, and plan how to use technologies, are still factors (Webster, 2007) that are unlikely to disappear any time soon. However, things have begun to change over the past fifteen years, as technology became increasingly flexible, affordable, and usable in the classroom, and a number of prototypes and studies started to appear. For example, Bamberger (2003) created composition software that worked at both the note level, and the "block", or phrase, level. Studies of musically untrained students, demonstrated that they were able to intuitively navigate a large amount of melodic material, and produce archetypal tonal melodies. Perhaps not so coincidentally, much of the work developed in this thesis is inspired by this very same idea. Siegel (2004) reports on a project for 3-5 graders in which students, as a group, composed music based on poetry that they also wrote. This is, in fact, another idea that has been incorporated in this thesis. Denis et al. (2005) made a case for conveying knowledge through interaction – i.e., games – as opposed to navigating static data. The notion of learning by doing permeates this thesis entirely. Truman (2008) showed that carefully designed technology can help introduce pupils to complex musical tasks, such as composition. Xambó et al. (2013) showed how spontaneous learning occurs within a group of people collaborating over a tangible musical interface. A comprehensive review of the use of technology in music education was published by Webster (2007), and later updated (Webster, 2012).

The problem of getting novices to compose music cannot be tackled only by technology. It is hard to get novices to compose meaningful music, while at the same time affording them a safe playground in which they can practise concepts of music theory and composition. While highly motivated novice students may accept focussed and repetitive exercises, requiring them to play or compose a few bars to show mastery of musical concepts, this may not be true for all of them. These types of exercises, assigned without appropriate context or motivation, may risk seeming meaningless and boring to beginners who may need extra motivation to face difficulties. This may in turn lead them to drop out of an activity that they may have taken up expecting to enjoy (Costa-Giomi et al., 2005). Furthermore, there is no reason why beginning students should not be encouraged to compose music before they are able to play it on their chosen musical instrument. As mentioned above, a committed student has the necessary motivation to overcome the initial difficulties that music studies inevitably pose, regardless of where this motivation comes from (Smith, 2005). However, this thesis is aimed at those novices who are not yet fully committed to music studies, and may benefit from engaging in exercises that they can consider meaningful and interesting. In this way, they have the chance to create their own goals and expectations to motivate and guide them. In the words of Paynter (2000), "*when anyone has tried putting sounds together and is pleased with the results, enough to remember them, the teacher can start to teach – mainly by asking questions about what is presented*".

Music composition exercises can be framed in many ways, and these can be critical in setting expectations and motivation in novices. Referencing extra-musical elements can be a useful device when asking novices to compose music (Truman, 2008). Elements such as physical objects, scenery, paintings, as well as literature and narrative, are often used by professional composers, and can provide a starting point in any discussion of musical concepts. By suggesting associations between the musical and the extra-musical domains, novices have a chance of creating their own understanding of the musical concepts.

For these reasons, the approach adopted in this thesis was to set up music composition exercises that reference extra-musical materials, such as an abstract painting with strong geometric elements, for the study of melodic contour presented in chapter 4, and storytelling for the study of melodic similarity and contrast presented in chapters 5 and 6. An abstract painting was also used in the pilot study presented in chapter 3.

1.1. Terminology

The following is a summary of the key terms used in this thesis, which will be explained in chapter 2.

Tangible User Interface (TUI)
: A type of user interface in which a person interacts with digital information through physical objects that provide a representation of the qualities of this information. The physical object acts not only as an affordance for manipulating digital information, but also provides a conceptual link to the information, so that the manipulation itself acquires meaning (Ishii, 2008).

Digital Tabletop Interface (DTI)
: A type of TUI in which interaction occurs on a screen, or on a projection surface that recognises touch and/or objects as input from users, that can provide visual feedback about its operations, that lies flat like a table, and that is large enough for at least two users to work together or independently.

Digital Tabletop Musical Interface/Instrument (DTMI)
: A DTI that runs a synthesiser that users play through the screen, and that allows users to play music by improvising – like a musical instrument – and/or by composing – like a music composition application. This thesis is concerned with DTMIs, thus the terms “interface” and “instrument” are sometimes used interchangeably.

1.2. Education support tools

Within the class of TUIs, digital tabletops have certain qualities that make them interesting for music making, and for music education. Digital tabletops allow users to visualise and manipulate complex and intangible information, such as music. In particular, two qualities stand out in relation to education: the combination of the flexibility of the digital medium (Catala et al., 2012), and the digital tabletop’s ability to provide a link between the digital and physical world that invites action or reflection through different types of feedback (Cuendet et al., 2012). These qualities suggest that digital tabletops may be able to help beginners make sense of music through experimentation.

1.3. Aim of this thesis

This thesis addresses the following overarching research question.

> How can we design a Digital Tabletop Musical Instrument that can support people in discussing musical concepts, and in using such concepts to compose music?

The question is motivated by the observation, rooted in the literature, that Digital Tabletop Musical Instruments (DTMIs) are a promising platform for music education and music-making, and in particular for collaborative music education and music-making by both novices and experts. The approach adopted in this thesis is twofold:

- to design and evaluate a DTMI that allows users to make music using certain specific musical concepts;
- to design and evaluate several DTMI-supported learning activities aimed at helping users to acquire such musical concepts, and use them to discuss and compose music.

The aim was to explore the role of digital tabletop musical interfaces in the context of music education, focusing in particular on non-musicians, and novice music students.

1.3.1. Sub-questions

The question was refined to specify the musical concepts investigated in the three studies presented in this thesis, and several sub-questions were introduced in each study. These sub-questions related to various aspects of each study, but in general they can be summarised as follows.

- How do people understand the musical concepts investigated in the study, and how do people use these concepts to discuss and compose music?
- Does the DTMI provide adequate support for people to acquire the musical concepts investigated in the study, to the point of being able to describe and compose melody using these concepts? Or does it pose challenges that prevent people from understanding and discussing the concepts and using them to make music?

In addition, throughout the three studies, issues with individual use and group collaboration were investigated.

1.3.2. Break-down of the question

The question mentions “users” without qualifying whether they are novices or experts. There are two reasons for this choice: first, during the research design phases, the difficulty of obtaining a reasonably sized sample of novices became clear, as many potential participants had received some form of music education at some point; second, this choice made it possible to investigate the interplay between novices – i.e., people who received limited, if any, music education – and experts – i.e., people who have received some form of music education – around the DTMI, and how they might inform each others’ understanding of the musical concepts being explored.

The question is purposely general regarding the musical concepts. Chapter 4 presents a study in which users learned about melodic contour, a visual metaphor used to describe melody. The study explores the way in which users make sense of the visual metaphor to describe a painting using music. Chapters 5 and 6 present two studies in which users learned about the concepts of similarity and contrast in melody, and how these are used to create musical structure and narrative. In Study 2, participants worked individually, whereas in Study 3 they worked in a group.

1.3.3. Design and research methods

Given the interest generated by multimedia and tangible technology within education, one would expect a sizeable body of research, design methods, and guidelines to exist. Yet, although the situation has been improving in recent years, this is hardly the case (Kharrufa et al., 2013b). Research on TUIs, and on digital tabletops in particular, is typically situated at the intersection of Human-Computer Interaction and the disciplines that the particular TUIs under investigation apply to. This is very helpful, as it allows us to borrow research methods from HCI, among other fields. A combination of different quantitative and qualitative methods is often used, and these typically produce rich and insightful analyses (Xambó, 2015). However, guidelines for the design and evaluation of TUIs in education, and of tabletops in particular, are still vague at best, and comprise a series of methods and techniques that may or may not be used, at the discretion of the designers and researchers.

All of the empirical work presented in this thesis is exploratory, and qualitative in nature. We need to understand what are the issues and the phenomena that this application of digital tabletop technology raise, before proceeding to ask more focussed questions, and perform quantitative experimental work (Easterbrook et al., 2007).

1.4. Thesis roadmap

The subsequent chapters of this thesis are structured as follows.

- Chapter 2 provides a survey of the literature in the area of Tangible User Interfaces, focussing on their strengths and weaknesses in relation to music, and providing a rationale for DTMIs as music education support tools.
- Chapter 3 presents an overview of the methodology used for collecting and analysing data in the three studies presented in this thesis, along with the description of a pilot study aimed at testing the technology and methodology. Lastly, based on the findings from this pilot study, the

chapter introduces the DTMI developed for the three studies.

- Chapter 4 presents a study in which individual participants explored on their own the concept of melodic contour as a visual metaphor for describing and composing melody based on an abstract painting, using the DTMI as a music composition platform.
- Chapter 5 presents a study in which individual participants explored, with the help of a tutor, the role of melodic similarity and contrast in describing, and composing, melodies that suggest narrative, using the DTMI as a support and as a music composition platform.
- Chapter 6 presents a study based on the study in Chapter 5, but involving groups of participants of different levels of musical experience. Additionally, the study investigated how the participants discussed and developed their understanding of the musical concepts as a group, using the DTMI as a discussion mediator and music composition platform.
- Chapter 7 summarises the findings and suggests future research in DTMIs as music education support tools.

2 Literature Review

2.1. Tangible User Interfaces

A Tangible User Interface (TUI) is a type of computer interface in which a user interacts with digital information through physical objects that provide a representation of the qualities of that information. The physical objects act not only as controls for manipulating digital information, but also as conceptual links to it, so that the manipulation itself acquires meaning.

TUIs are special purpose interfaces that are tightly coupled with the systems that they represent (Ishii, 2008). For this reason, there is no single typical example of a TUI, but a wide variety of research prototypes and commercial products exist, each tailored for a particular application. Although early prototypes of what now would be called tangible technology exist, such as Touch Display (Johnson, 1967), it was not until the middle of the 1990s that the idea of giving tangible – or graspable (Ishii et al., 1997) – form to digital information blossomed and began to attract academic and industrial attention.

Many TUIs, of different types and in different domains, can be seen as learning tools. The idea of improving learning by simultaneously engaging several senses is not new (Montessori, 1912), and its appeal is clearly reflected in the digital age by the vast number of TUIs developed with education in mind (O'Malley et al., 2004). Educational toys are not new: from the archetypical letter blocks to the modern LEGO Mindstorms, toys have always been, to some extent, intended as simplified preparations for adult life. Creating mental models through the exploration and manipulation of the physical world is a staple of constructionism, as proposed by Papert et al. (1991), and situated by

Maxwell (2006) in the context of educational technologies and media. Aiming at beginners, or the young, also allows designers to keep complexity under control, therefore avoiding some of the issues of TUI development – for example, scaling to large numbers of objects, limited screen estate or physical space – and to abstract out details that beginners do not necessarily need to address. The rest of this section presents several examples of TUIs in terms of the features that can make them viable as learning tools.

2.1.1. Problem solving, planning, simulation

Problem solving, planning, and simulation are areas for which some of the earliest TUIs have been developed. Urp (Underkoffler et al., 1999) is a tabletop TUI for urban planning that allows users to collaboratively analyse shadows, proximities, reflections, wind, and visual space. It provides scale models of buildings that can be placed on a surface onto which a map is projected. As users move these models around on the surface, the system simulates shadows being cast by the buildings, as well as wind flows, and other kinds of information. Luminous Table (Ishii et al., 2002) sought to improve on Urp by adopting a hybrid TUI/GUI approach to address some of the constraints that the pure TUI approach exhibited – i.e., physical space clutter and difficulty in tracking objects. Lastly, MouseHaus Table (Huang et al., 2003) is a pedestrian simulation for urban planning, in which users configure pathways by placing obstacles on the table, with the system simulating pedestrian flows.

Urban planning is not the only domain in which we can find TUIs for planning and problem solving. IP Network Design Workbench (Kobayashi et al., 2003) is a tabletop TUI that supports collaborative design of IP networks, allowing engineers and clients to simulate different network configurations and devise the best plan for their needs. Similarly, Pico (Physical Intervention in Computational Optimization, Patten et al., 2007) is a tabletop TUI that can track and move small special objects placed on its surface. Pico has been used to control an application that optimises the position of cell phone towers: special moveable objects represent the positions of the towers, and inert objects are tracked by the system and used to constrain the movement of the towers.

All these applications afford intuitive ways of configuring complex simulations and exploring the effects of different choices. They show that TUIs can reduce the complexity of some domains, while retaining the ability to perform sophisticated manipulations, to the point where domain experts (urban planners, communication engineers) and non-experts (citizenry, customers) can easily cooperate in selecting solutions that satisfy both parties.

2.1.2. Tangible programming

Tangible programming is the concept of constructing computer programs through tangible interfaces. This concept has been around for almost three decades (Perlman, 1976), and there is no shortage of examples, including a digital tabletop for introducing young children to LOGO programming (Gallardo et al., 2008), and a tablet version of Scratch to teach programming to young children (Flannery et al., 2013).

The term *tangible programming* was coined by Suzuki et al. (1995) to describe AlgoBlocks, a system of physical action blocks that can be assembled to solve problems. In their evaluation, Suzuki et al. (1995) developed a videogame in which the character is controlled by assembling AlgoBlocks to solve different on-screen puzzles. Similarly, OHR (Menestrina et al., 2014) is a puzzle game in which players use physical controls that can be plugged into a board to configure a virtual stage and allow the character to progress through the game. Many tangible programming systems employ the *constructive assembly* metaphor (Ullmer et al., 2005), primarily providing physical objects that can be combined to describe an algorithm that is then run by a computer, or by the objects themselves. For example, Topobo (Raffle et al., 2004) is a 3D constructive assembly system in which small connectable blocks are used to create animal-like models. Some Topobo blocks include motors in the joints that can record and replay their movements, thus creating toys that ambulate. Changibles (Roudaut et al., 2014) are blocks that can be combined and programmed through a projection surface to create animated models. Many other tangible programming systems have been proposed, from Papert's pioneering Digital Construction Set (McNerney, 2004) to Tern (Horn et al., 2008) and Electronic Blocks (Wyeth et al., 2002).

Tangible programming applications have been designed as learning toys, with very few exceptions. However, evidence that such toys deliver educational benefits beyond those provided by visual programming languages has only recently started to appear. In a recent study, Sapounidis et al. (2015) compared children's performance using a TUI and an equivalent GUI programming language. The children had to program a toy robot by connecting commands that were represented by physical cubes, in the TUI variant, or by virtual cubes, in the GUI variant. The authors of the study found that younger children generally performed better with the TUI, whereas older children performed better with the GUI – perhaps, the authors speculate, because they are already used to computers. Horn et al. (2009) performed a similar study, finding that the TUI was better than the GUI alternative at attracting and retaining users, and also that girls were more attracted to the TUI. They argue that, as technology's presence in society grows, it is important that it supports all members of that society. In a later review of their work, including the 2009 paper cited above, Horn et al. (2011) highlight the importance of selecting the right tool for the job. In their words, they "*advocate for a hybrid approach—one that offers teachers and learners the flexibility to select the most appropriate interaction style to meet the needs of a specific situation*".

2.1.3. Presenting information

Some applications do not require users to manipulate data. This is the case, for example, of interactive displays aimed at presenting information, such as the location of the shops in a shopping centre, or additional information about particular items in an exhibition (Hinrichs et al., 2013).

Digital tabletops used as interactive displays are becoming a common sight in shopping centres, showrooms, and tourist information centres, primarily in the form of pure touch-screens. In these settings, they are often used to present commonly sought information such as maps, points of interest, short audio-visual presentations, and, depending on location and purpose, interactive activities such as small games, quizzes, or feedback questionnaires. For example, The Gum Console (Dalsgård et al., 2006) is a showroom application that, in less than 5 minutes, will inform visitors about the company running the showroom and the contents of the showroom itself, and will attract visitors inside. Marshall et al. (2011) developed a shared visit-planning application to be deployed in a tourist information centre. In this scenario, groups of users walk up to the table and start planning their day out together. The developers initially assumed that families or groups of friends would approach the table together, but a study conducted in an actual tourist information centre revealed different usage patterns. In particular, cohorts would first disperse upon entering the centre, and then approach the table when one member noticed it and called the others. Furthermore, a significant minority of users had problems understanding how to begin using the system, and others were confused by the interaction mechanics, which clashed with people's expectations in front of a touch-screen. These observations led Marshall et al. (2011) to conclude that "*better scaffolding of user interactions*" is needed. In general, it has been argued that developing TUIs is currently problematic. On one hand, User Interfaces are in general inherently hard to design and implement (Myers, 1993), mainly due to the fact that designers and programmers cannot always be familiar with the typical users and tasks of a certain application (Gillan et al., 1990). On the other hand, although the situation has improved in recent years, TUIs lack solid development infrastructures, both at the conceptual level – including guidelines, patterns, and so on – and at the software implementation level (Shaer et al., 2010).

Museums and galleries are beginning to use digital tabletops as part of their exhibitions, and both the pure touch-screen and the hybrid TUI varieties are used, depending on their purpose. The ability to walk up to the table and quickly navigate multi-media information is arguably desirable in crowded spaces where traditional displays may not be feasible. For example, providing access to otherwise inaccessible information was part of the goal of the Engaging Constable installation at the Tate Britain (vom Lehn et al., 2007), where visitors could perform a virtual X-Ray examination of John Constable's paintings, or discover them through the painter's own sketches. In a similar spirit, Inside Explorer (C-Studio, 2012) allows users to explore subjects scanned with various medical imaging systems. Providing access to large collections that would otherwise take up considerable physical space is another typical use for digital tabletops in museums. Digital platforms allow visitors to view large quantities of items, and obtain more information about them than could reasonably fit in a typical information panel. Furthermore, digital tabletops may also allow visitors to actively engage with the collection, for example by tagging items and exploring the semantic relations between items in the collection (Correia et al., 2010).

Museums inform and educate, but they also aim at entertaining. Build-a-Tree (Horn et al., 2012) is a touch-screen tabletop game aimed at explaining evolution by building phylogenetic trees that highlight shared derived traits in living organisms. The evaluation done by Horn et al. (2012) suggests that digital tabletop games have the potential to engage museum visitors in a productive collaboration by exploiting typical social practices of game play – such as turn taking, narration, reflection on outcomes, and so on. Tree of Life, at the Berlin Museum of Natural History (Hornecker, 2008), takes a different approach to the subject of evolution. Rather than a game, Tree of Life is an information browsing application that presents a variety of materials that are accessed through questions floating on the surface. A visitor selects a particular question – such as "*are marsupial young born inside the pouch?*" – and that brings up the answer, as well as additional information on the subject. However, an evaluation performed by Hornecker (2008) showed very little engagement with the information, and almost no discussion between users. The authors speculate that this could have been an effect of the particular data collection procedures put in place to comply with the German privacy law.

When it comes to presenting multi-media, multi-layered information, the vast majority of prototypes and products employ some form of hybrid TUI/GUI approach. While it is possible to present information with simple physical objects, complex information typically has to be broken down into smaller chunks and be represented by a number of different objects (Ishii et al., 1998). It is therefore legitimate to wonder how physical complexity might scale as the complexity of the information increases.

2.1.4. Music

Music is a popular area of application for TUIs (Shaer et al., 2010). Music is often considered difficult to engage with, past the listening level. This may be partly because the experience of music, especially as a listener, is mainly aural, therefore lacking visual and graspable dimensions. Such dimensions may make it easier for people to construct mental models, as discussed in section 2.2.

Defining what a musical TUI is can be difficult and confusing. Musical TUIs come in all shapes and sizes, because virtually anything with some sort of sensing capability can be made into one, by mapping the output of some sensors to the input of a software synthesiser. Long before Apple's iPad popularised multi-touch interfaces for music making, tangible and multi-touch musical instruments had begun to appear in both academic and non-academic settings, including on the market and on stage – many examples of which are presented by Fels (2004) and Miranda et al. (2006). JazzMutant's Lemur was allegedly the first personal multi-touch controller for MIDI and OSC-based musical equipment (JazzMutant, 2005). Tangible controllers can, however, be as ordinary as a keyboard: for example, a piano is composed of sound-producing elements – the strings – that are struck by hammers, which are in turn set in motion by pressing keys on the keyboard. Following this line of reasoning, it is difficult to produce an unequivocal definition of a musical TUI. Perhaps a better example would be the electric console of a pipe organ. Such a console comprises a set of keys, pedals, and stops, the state of which is encoded as analogue electrical signals. These signals are in turn transmitted to electro-mechanical actuators that operate the sound-producing elements of the instrument. However, it is entirely possible to turn these analogue electrical signals into digital signals that can be used to control a software synthesiser. Vice versa, it is possible to control the sound-producing stage of the organ through software, by turning digital signals into analogue electrical signals that are appropriate for the instrument's actuators. In this thesis, a tangible musical interface is considered to be (i) a TUI that separates the act of producing sound from the act of controlling the production of sound, and (ii) a TUI that allows the performer to focus less on the mechanics of sound production and more on controlling sound qualities and the overall performance, as described by Jorda (2008). Within this definition, we can categorise musical TUIs by their high-level approach to sound and music as *controllers*, *sound toys*, *sequencers*, and *instruments* (Shaer et al., 2010). Products such as the Lemur and TouchOSC (Fischer, 2008) are considered *controllers*.

A *sound toy* is a musical TUI with specific sound capabilities and simplified controls. Iwai and Yamaha's Tenori-On (Nishibori et al., 2006), for example, is a square grid of buttons that produce sound when pushed, and that can be programmed and played back in loops. Squeezables (Weinberg et al., 2001) are gel balls equipped with sensors, the outputs of which are mapped to a software synthesiser to play music. The PebbleBox, the DaGlove, the Crumble Bag, and the Scrubber (Essl et al., 2006) are all experiments of TUIs for granular synthesis, in which the physical properties of each artefact are mapped to aural and control parameters of a granular synthesiser. The distinction between a controller and a sound toy can sometimes be blurred. It is true that actions performed on a sound toy can be mapped to any synthesiser, but the aural intent is often clear from the physical appearance of the toy, while controllers tend to have a more generic physical appearance that can be mapped to many different sound processes.

A tangible *sequencer* is a musical TUI that allows users to sequence, mix, and play audio samples. The Augmented Musical Stave, the Tangible Drum Machine, and the Physical Sequencer (Costanza et al., 2003) are three examples of tangible sequencers that take the well-known piano roll interface employed by many software sequencers, and implement it with physical objects on a surface. Block Jam (Newton-Dunn et al., 2003) is a TUI that uses blocks to control a polyrhythmic sequencer in a way reminiscent of tangible programming. AudioPad (Patten et al., 2002) is a digital tabletop that uses electronically tagged pucks to represent both audio samples and effects, allowing users to create music by processing and mixing audio samples. Similarly, mixiTUI (Pedersen et al., 2009) allows performers to import a collection of audio samples and create sequences using these samples. The focus of mixiTUI is not on sound generation as much as it is on allowing performers to plan a live performance, a focus that the authors of that paper feel is often lacking in other musical TUIs. The difference between musical toys and sequencers is that sequencers typically have wider sound capabilities, by virtue of their focus on audio samples and processing. On the other hand, focussing on audio samples may take away from performers the ability to express themselves by directly controlling the sound generation in the way that musical toys allow.

A tangible *musical instrument* is a synthesiser that can be fully controlled by the users. A notable example of a tangible musical instrument is the Reactable (Jordà et al., 2005), a full modular synthesiser with a tabletop interface on which special blocks and finger touches control the synthesiser's parameters and functions. The Kaossilator (Korg, 2007) is a portable synthesiser that is operated through a touch-pad, and works as a synthesiser and step-sequencer The AlphaSphere by nu desine (Place et al., 2014) is a synthesiser based on elasticated pads that respond to touch, velocity, and pressure, and that can interface with synthesisers and samplers. Tangible musical instruments give players control over many different aspects of music making. From sound generation to sound processing, from sound layering to sequencing, players have considerable control over which features they want to control and which they prefer to leave to the machine. Furthermore, digital tabletop musical instruments, such as the Reactable, provide visual feedback that can help novices to understand the instrument and how they can use it to express their musical intentions.

2.1.5. TUIs in music education

TUIs have been researched widely over the past two decades, and they are today far from being exhaustively understood. Different types of TUIs support different types of applications better than others, and interfaces of greater or lesser complexity are being developed to provide physical access to varying degrees of complexity in the underlying system.

The review of the literature on TUIs brings up some interesting general points.

1. The question of scale: simple objects can represent only so much of the underlying system. Changibles (Roudaut et al., 2014) showed that TUIs could consist of more than simple pucks and blocks, although it is reasonable to wonder how far we could go without making these objects too fragile to handle (Costanza et al., 2003), making the technology a "lesson stopper" when used in an educational context (Rode et al., 2003). Luminous Table (Ishii et al., 2002) addressed the increasing complexity of the underlying system by incorporating GUI elements into the TUI, in order to reduce clutter on the surface. Music, having numerous features and levels of abstractions, seems like a good candidate domain to investigate the issue, and in fact many tangible musical instruments already exist in the form of digital tabletops.
2. The role of TUIs as education support tools: intuitively, TUIs in education and edutainment make sense. It has been argued that physical manipulation may provide additional insights compared to pure mental modelling (Zuckerman et al., 2005). It has also been shown that the flexibility afforded by manipulating purely digital objects could lead to more complex outputs and solutions (Catala et al., 2012). However, evidence suggests that the way in which a TUI is designed in relation to a particular task can have a detrimental effect on the strategies employed by users to perform that task, in particular affecting the educational outcome (Cuendet et al., 2012). It is therefore legitimate to wonder how we can design TUIs as education support tools.
3. The limited knowledge that designers and researchers have of how to design, implement, and evaluate TUIs. TUIs This type of interfaces are considered difficult to design and build (Shaer et al., 2010), and in fact most of them are prototypes emanating from research labs: very few

> make it out of the labs and into the marketplace. TUI developers have to face many of the challenges associated with the design and evaluation of traditional user interfaces (Myers, 1993). In addition, they also face TUI-specific issues, such as the scarcity of appropriate development tools, and limits in the cross-disciplinary knowledge required to connect virtual and physical environments effectively (Shaer et al., 2009). Manufacturing costs can be substantial for one-off prototypes, and robustness, ease of deployment, and user safety are often issues.

Units of information such as operations, motion, positions, can be encoded into physical objects such as cubes, pucks, and motors in intuitive ways. However, there is no use in knowing that a block moves a game character forward, or that a cell tower is in a particular location, if these pieces of information appear in isolation. In fact, in all the examples discussed so far, these units of information become meaningful only when combined with each other. It is then legitimate to reflect on the extent to which we can expect the complexity of the information to increase while still remaining accessible through a TUI: is there a point where a traditional GUI may be more effective than a TUI at presenting and manipulating information? GUIs have a clear advantage over TUIs: they represent information through manipulating a grid of pixels in a way that can graphically emulate a variety of media. However, GUIs traditionally decouple representation – pixels – from control – input devices – and this is inconsistent with the way we interact with the rest of our physical environment (Ishii, 2008). Marshall (2007) wonder if "*tangible interfaces* [are] *really any better than other kinds of interfaces*". The evidence is contradictory, and the general consensus is that we do not know.

However, the question that Marshall (2007) ask is problematic. Arguably, some TUIs fit some applications better than other kinds of interfaces. Therefore it would make more sense to ask: for what applications are TUIs better than other kinds of interfaces? One could indeed pick any combination of TUI and application and systematically research each of them. However, the literature surveyed in this section already points towards digital tabletops as tools for computer-supported collaborative learning (CSCL) (Dillenbourg et al., 2011). According to Marshall (2007), this is an area that is sparsely investigated and where most user studies are "*largely informal evaluations that tend to be positive*".

Education is a recurring theme across the literature on tangible user interfaces. Many novel technologies, including TUIs, have been touted as the "next revolution" in education. Technology has had an undeniable impact on education (Muller, 2014), so the area is clearly appealing. However, has technology affected education as profoundly as to justify claims of a "revolution"? According to Muller, learning is a social activity in which knowledge is mediated by a teacher who guides and motivates learners through the process. Analogous findings are present in the literature (Wentzel, 1998), and in particular that of music education, where the influence of teachers was found to contribute to motivation and self-confidence, particularly for younger students (Sichivitsa, 2007).

To summarise, digital tabletops have potential as education support tools, and music is a popular application that resonates with research and industry. So, the question is: what are the implications for digital tabletops in the context of music education?

2.2. Digital tabletop musical instruments for music education

Among the properties of tabletop interfaces, two stand out in relation to music: first, the ability for multiple users to work together as they would around a regular table, exploiting typical social practices of co-located cooperative work; second, the potential to present complex, even intangible, information in a simplified, concrete way.

2.2.1. Collaboration

Research on digital tabletops is often concerned with collaboration, and in particular it covers issues such as sharing control and resources, and the emergence of hierarchies in group work. For example, Morris et al. (2004) and Wang et al. (2006) investigated ways of coordinating work around the shared environment created by a digital tabletop. Morris et al. (2004) identified coordination issues and proposed a set of policies to resolve them. Wang et al. (2006) also found that artificial interventions may be detrimental in the group work, whereas instead Hornecker (2008) found that participants to the group activity may be able to create their own special ways of resolving conflict situations.

Music performance is often a group activity, and effective communication and conflict resolution can be crucial in creating a positive experience. The role of communication between musical agents is explored by Linson (2014), in which human musicians engaged in free improvisation with a purposely built AI. A common complaint from the musicians was that the AI often seemed to communicate with them at too shallow of a level, by replicating the same phrase over and over instead of suggesting variations based on the past performance and musicians' responses. Further on the theme of communication, Laney et al. (2010) found that both shared and individual spaces are conducive for an engaging collaboration. Xambó et al. (2013) also highlight the importance of verbal communication, when considering aspects of collaborative learning. However, they also found that non-verbal communication, and in particular mimicking the actions of others, has a considerable impact on learning how to use the platform – the Reactable, in this case – and the concepts behind it.

Collaboration within a shared physical space is indeed a strong trait of tabletop interfaces, as shown by Xambó et al. (2013) among others. Collaboration proves effective in allowing the users to share and acquire knowledge about the tabletop interface as well as about the tasks at hand, especially in heterogeneous groups where experts and novices work together (Xambó et al., 2013)

2.2.2. Concreteness

As discussed in sections 2.1.3 and 2.1.5, digital tabletops mix the flexibility of GUIs and the physicality of TUIs (Ishii et al., 2002), and by virtue of this, they are arguably good candidates for manipulating complex systems. Music is, in fact, inherently abstract and intangible (Wiggins et al., 2010), and therefore often perceived as difficult to understand – at least in the Western world, where musicians engage in the study of music theory, a corpus of musical forms and rules that can appear intimidating and puzzling to the uninitiated.

Digital tabletops are especially good at making music less intangible, and more concrete, by virtue of interactive visual feedback: Jordà et al. (2007) argue that, in tabletop interfaces, the "*seamless integration of visual feedback and physical control allows* [...] *for more natural and direct interaction*". In fact, chapters 4 to 6 show that representing music in a simplified visual form plays a role in helping novices explore unfamiliar concepts, make sense of them, and use them proficiently to compose melody.

2.3. Summary

Section 2.1 presented a general overview of TUIs, highlighted their key elements, and argued how these elements stand in relation to education. In particular, it was discussed how TUIs can provide simplified, yet expressive representations of complex systems, so that experts and novices can collaborate in meaningful ways. Section 2.2 discussed the desirable qualities that DTMIs posses in relation to music-making, and musical education, namely:

- allowing users of different levels of musical experience to collaborate in ways that are expressive, understandable, and meaningful for them;
- making the intangible domain of music available to users through visual and tangible representations.

In summary, in this chapter it was argued that music is a promising application domain in which to investigate digital tabletops as education support tools. Rigorous research on the subject is beginning to appear, and education-specific frameworks – such as that proposed by Dillenbourg (2013) for orchestrating complex educational activities – are increasingly being used in real-world scenarios (Kharrufa et al., 2013a). However, research on digital tabletops as support for music education is today in its infancy, with only a handful of exploratory studies conducted in the past five years, therefore this thesis will investigate practical and methodological issues of digital tabletops as music education support tools.

3 Methodology

This chapter offers an overview of the methods and materials used in this thesis. Section 3.1 presents the general mixed methods approach undertaken for all of the three studies presented in chapters 4 to 6, and argues that it is an appropriate approach for this type of research. Some of the issues with this approach, and how they were addressed, are also considered in this section. Section 3.2 reviews the specific research tools that were chosen to collect and analyse data, in accordance with the overarching research question stated in chapter 1. Subsequently, section 3.3 presents the development and execution of a pilot study designed to test and refine the methodology in order to achieve a reasonable balance between resource usage and results quality. Lastly, the way in which these preliminary results informed the development of the application that was used for all the three studies is discussed. Further details of the methodological approach used in each study, as well as details on participants, procedures, methods for data collection and analysis, and limitations are provided in chapters 4 to 6.

3.1. A mixed-methods exploratory approach

It is fair to say that research on digital tabletops is a developing and relatively young field, but it is also true that, as a sub-field of HCI, it can profit from many of the already well-established research methods commonly used in the discipline. HCI research is no stranger to mixing quantitative research approaches with qualitative approaches that are often inspired by research in psychology and social sciences. In fact, it is often the case that researchers seek to understand how and why users behave and react as they do while interacting with a computer system. Therefore, researchers need to observe users' behaviour, and inquire into their thoughts and views.

Qualitative research is often problematic in terms of the validity of its results (Sandelowski, 1993), as well as in terms of the amount of work that it can require to produce such results. This section discusses how mixed methods deal with the question of validity, and how the work presented in this thesis deals with issues of volume.

3.1.1. Validity

Data acquired with mixed methods (Johnson et al., 2007) can be used to produce rich analyses that seek to explain why and how certain phenomena happen, and to draw conclusions that can be considered valid even with small samples. In fact, in exploratory studies – like those presented in this thesis – sample size can be an issue, and claiming statistical significance may be impossible. The question of rigour in research comprising a qualitative part is often brought up (Sandelowski, 1993), as it clearly represents an issue.

Qualitative research has been sometimes characterised as almost a form of art (Sandelowski, 1993). The validity of the results that it produces is subject to various threats, not the least of which is the researchers' ability to interpret the data and draw sensible conclusions. Mixed methods, as defined by Johnson et al. (2007), embed ways of dealing with validity and rigour issues, such as *triangulation* (Rothbauer, 2008), a technique used in social sciences to validate findings through cross verification from multiple data sources. The core idea is that a result is more valid the more other methods point to the same conclusions.

In the research presented in this thesis, the analysis consistently attempts to triangulate in this way. This is done by looking for evidence across the entire data set that can support a finding from a particular type of data. For example, if video evidence shows that one participant becomes disengaged, the post-session questionnaire claims that the participant did not enjoy the session, and the participant comments in the debriefing about not being happy with the artefacts they produced, then it can be confidently said that the session had a negative impact on the participant. However, if video evidence shows that one participant becomes disengaged, and the post-session questionnaire claims that this participant did enjoy the session, more evidence may be necessary to explain this circumstance. As should be clear from the example, triangulation is hardly the silver bullet of qualitative research. However, if applied sensibly, it can lead to more credible results than if those results were left standing on their own.

3.1.2. Volume and scalability

The ways in which data are collected and analysed are an integral part of a study's design: it is important that researchers have enough evidence to support their conclusions, but it is also important that the amount of collected data does not require excessive resources to be analysed. How much is "excessive" is not always easy to judge, but fortunately the literature relevant to this research, Xambó (2015) in particular, can provide some guidance.

The range of different data collection and analysis techniques in HCI can be wide, depending on the questions that the researcher is trying to answer. For example, audio recordings of users thinking aloud can be useful in determining causes of inefficiency or failure, and video recordings can focus on non-verbal communication and behaviour, providing a detailed account of what actually happened, as compared to participants' reports of what happened (Jordan, 1996). Post-session reflection interviews, in which researchers and participants re-examine such recordings, can also be useful in clarifying observations so that conclusions do not have to rely entirely on the researchers' intuition. Questionnaires and structured interviews are often used to collect users' opinions so that their answers can be directly related to a pre-conceived framework. Application logging can be invaluable in integrating *in vivo* observations, as well as in providing data that may otherwise be unfeasible to obtain by other means – such as interaction times, patterns, task-completion rates, and so on. These are just some of the commonly used techniques in HCI research (Lazar et al., 2010), and it is unsurprising that analysis can quickly become a demanding task. This does not, however, mean that a technique is undesirable just because it requires too much work: it means instead that each technique has to be carefully evaluated against the research aims. Studies such as those by Xambó et al. (2013) are a testimony to the fact that meticulous and detailed analysis of many hours of video recordings is indeed worthwhile, when such a level of detail is required.

3.2. Data collection and analysis

A good data collection and analysis strategy has to be grounded in the research question, so let us recall the question formulated in chapter 1:

> How can we design a Digital Tabletop Musical Instrument that can support its users in discussing musical concepts, and using such concepts to create music?

This section describes the data collection and analysis methods and techniques used in this thesis, with reference to the most relevant literature on collaborative and tabletop music making.

3.2.1. Data Collection

The question references two fundamental themes: how users work with a musical interface as a device for discussing musical concepts, and how they use the interface to create music. The question also mentions the design of an interface: it is customary in HCI research that, when one builds an interface, a formal evaluation phase follows. In this research, the need for this phase was reduced by practical considerations that will be discussed later in section 3.4. Evaluation was not ignored, but rather implemented in a lightweight way that nonetheless provided useful feedback and suggestions for improvement, as will be discussed further in section 3.3.

In order to investigate the two themes referenced by the question, a range of data collection techniques was used, some inspired by the work of Fencott (2012) on collaborative co-located music making, and by the work of Xambó (2015) on collaborative tabletop music making.

Video recordings arguably produced the richest part of the data set, by providing an exact record of what people did and said during the experimental sessions. The recording set-up was identical for all the studies: a single camera mounted on a tripod placed in close proximity to the activity area, so that both the tabletop surface, and relevant – but not identifying – features of the participants could be recorded – including hands, stance, spatial location, and so on.

Questionnaires were administered to collect demographic data – such as previous musical experience, self-confidence in musical abilities, and so on – as well as the participants' feelings and views after participating in each session. All the questions that were not related to demographics required answers on a 5-level Likert scale. The participants were also encouraged to leave comments if they felt it would help clarify their Likert answers.

Interviews were carried out depending on the specifics of each study. These ranged from semi-structured interviews to open-ended discussions – both with the researcher and with fellow participants where group work was part of the session. These were intended to stimulate the participants regarding the contents of each session.

Worksheets were used to provide guidance to the participants in carrying out the activities required by each study. Each study had different forms of worksheet, ranging from simple instructions printed out on paper, to a series of questions, or steps to follow. In the second study, chapter 5, the worksheet was implemented by the tabletop interface, as a series of exercises, while instructions regarding the exercises were provided to the participants by the researcher, acting as a tutor.

Application logs were collected by the tabletop interface while in use, in order to gather evidence of usage patterns and times, as well as to record the musical artefacts where necessary.

3.2.2. Data analysis

Each of the studies aimed at understanding what the role of a DTMI in music education could be. Therefore, it was necessary to investigate whether and how people made sense of, and used, the technology in exploring the musical concepts that they were asked to work with. This line of inquiry led to a largely exploratory study design (Easterbrook et al., 2007) and qualitative data analysis (Lazar et al., 2010), as it was important to understand how people behaved, why they did so, and whether the technology supported them in, or was an obstacle to, their activities. The way in which the music making tasks were framed meant that there were no right or wrong answers: instead, the tasks were designed to demonstrate whether or not participants made sense of, and could use, the musical concepts.

Thematic analysis

"*Thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data*" (Braun et al., 2006). In their seminal paper, Braun et al. (2006) review and summarise the current state of the art in the practice of thematic analysis, and provide a detailed guide on how to perform it, in the form of the following six phases:

1. *Familiarizing yourself with your data*: examining the data repeatedly, transcribing them if necessary, and annotating them including initial ideas, preliminary forms of classification, and so on;
2. *Generating initial codes*: identifying interesting features in the data, and coding them systematically, so that different data sources can be collated;
3. *Searching for themes*: the codes generated in the previous step are classified into broader categories that pertain to the research questions, and can potentially become themes;
4. *Reviewing themes*: the themes generated in the previous step are checked in relation to the codes, and the data set, in order to make sure that they "make sense";

5. *Defining and naming themes*: the details of the themes are refined, and the overall narrative of the analysis emerges;
6. *Producing the report*: the analysis is detailed in a rigorous report, and is related to the research questions and the literature.

Thematic analysis can be done in two ways: inductive, or "bottom up", and deductive, or "top down". Thematic analysis conducted inductively generates themes that are strongly linked to the data, and thus provide typically rich descriptions that are not necessarily driven by the researchers' analytic preconceptions. Conversely, thematic analysis approached deductively analyses the data according to the researchers' analytic interest, thus producing descriptions that are generally less rich, on the one hand, but more focused and detailed on certain aspects of the data, on the other. Furthermore, thematic frameworks developed previously by the same, or other, researchers are often used in performing thematic analysis in a deductive way.

In this thesis, thematic analysis was approached in both ways, depending on the aspects to be analysed. In particular, the usability analyses were conducted using a thematic framework inspired by Hornecker et al. (2006). This framework aims at covering many different forms of tangible and embodied interaction, therefore the themes that were used in the analyses presented in this thesis were modified versions of those proposed by Hornecker et al. (2006). On the other hand, the analysis of the interactions, worksheets, and artefacts produced by the participants were analysed inductively, and the themes that were used, different in each study, will be introduced in the relevant chapters.

The following is an explanation of the themes proposed by Hornecker et al. (2006) that were used for the usability analysis of the DTMIs examined in this thesis.

Tangible Manipulation (TM) This theme covers the physical nature of the tangible elements that represent the information in the underlying digital system, and provide a link through which this information can be manipulated. Aspects that are analysed within this theme include:

- the users' ability to physically interact with the key elements of the system;
- the users' ability to learn the system, and its parts, in small, exploratory steps, and the ability of the system to encourage this type of exploration by virtue of the feedback that it provides;
- the ease with which the users are able to understand the relation between their actions, and the effect that these produce in the system;
- the ability of the system to provide representations of the underlying information that relate to the users' experiences, and that help the users to understand the information through these representations.

Spatial Interaction (SI) This theme covers the ways in which the physical objects are deployed in space, and the ways in which people interact with them by moving through, and using, this space. Aspects that are analysed within this theme include:

- the role that the interaction space has in providing the users with a meaningful experience;
- the use of space, and the positions of objects in space, as a way of interacting with the system;
- the ability of people to use their whole bodies to interact with the system.

Embodied Facilitation (EF) This theme covers the ways in which the physical configuration of the system affects the users' ability to interact with it. Aspects that are analysed within this theme include:

- the effect of the spatial configuration on the ability of its users to collaborate;
- the ability of all the users to see what is happening with the system, and to access and manipulate the central objects of interest;
- the ability of the representations offered by the system to exploit the users' experiences and skills in order to invite the users to interact with it.

Expressive Representation (ER) This theme covers the ways in which the representations offered by the system convey the qualities of the digital information, and allow users to use these representations to reason about it. Aspects that are analysed within this theme include:

- the ways in which the representations offered by the system become meaningful for the users, and help them to understand and manipulate the underlying information;
- the ways in which the users can use these representations to discuss and make decisions about the underlying information;
- the ability of the physical and digital representations to appear naturally coupled.

The nature of the interactive system used in this thesis – i.e., a large, touch-sensitive screen that was laid horizontal on a table – rendered the theme of SI of limited interest. However, there is some overlap between some aspects of SI and EF. Therefore, in the analysis of the studies presented in chapters 4 to 6, SI was not considered separately, while EF was modified to include elements of SI, particularly those related to visibility and to the affordance of access points.

In the pilot study described in section 3.3, an additional set of themes proposed by Bryan-Kinns et al. (2012) was used. This allowed the analysis of how the participants engaged with each other, and the ways in which the DTMI supported collaboration. However, these themes were found to overlap with those proposed by Hornecker et al. (2006), therefore it was decided not to re-use them in the subsequent studies. Nevertheless, they are presented here for completeness.

Mutual Awareness (MA) This theme covers the ways in which the system facilitates the users' awareness of each other, of the interactions between the users, and of what each user contributes to the collaboration. Aspects that are analysed within this theme include:

- the ability of all the users to become aware of who is contributing what to the collaboration;

- the ability of all the users to see what is happening with the system, and to access and manipulate the central objects of interest (EF).

Shared Representations (SR) This theme is used to understand whether the representations provided by the system make it easy for all its users to understand, and be aware of, the state of the system itself, and of the shared objects provided for the users to work. Aspects that are analysed within this theme include:

- the ability of the system to provide representations of the underlying information that relate to the users' experiences, and that help the users to understand the information through these representations (TM);
- the ability of all the users to see what is happening with the shared objects, and to access and manipulate the central objects of interest (EF).

Mutual Modifiability (MM) This theme is used to analyse the ability of all the users to manipulate each others' contributions. Aspects that are analysed within this theme include

- the ability of all the users to see what is happening with the shared objects;
- the ability of all the users to access and manipulate the central objects of interest.

Annotation (An) This theme covers the ability of the shared objects to provide a consistent record of decisions, thus supporting the users' discussion. Aspects that are analysed within this theme include:

- the ways in which the representations offered by the system become meaningful for the users, and help them to understand and manipulate the information (ER);
- the ways in which the users can use these representations to discuss and make decisions about the underlying information (ER).

Video recordings

Video recordings were at the core of the data gathering and analysis processes for studies 1 and 3. Video was instead not used in study 2 for the reasons presented in chapter 5. Each of these studies yielded several hours of footage that were both transcribed in text form, and reviewed in video form. Videos were watched in their full length at least three times each: once for producing the transcripts, once for annotating participants' interactions with the tabletop interface, and one last time for annotating interactions between participants. Transcripts therefore comprised not only speech, but also, when present and considered relevant, non-verbal cues, such as interactions with the tabletop interface, as well as interactions with peers when group work was involved. These transcripts were subject to further refinement: they were read again, and all the annotations were checked for internal consistency, and relevance to the objectives of the studies.

The transcripts were produced in accordance with the principles of interaction analysis proposed by Jordan et al. (1995). These were adapted for tabletop interaction, drawing inspiration from the work of Xambó et al. (2013). Focus was placed on elements such as:

- the sequence of events, including what actions were performed, and how;
- the temporal organisation of activities, including the alternation between verbal and non-verbal activity, and between types and patterns of participation;
- the use of space on and around the tabletop interface, including the use of personal and shared space on the interface, body positioning in the space surrounding the tabletop;
- the occurrence of work on shared objects, for example people modifying somebody else's work;
- and the role of the DTMI and the artefacts, including the discussion of the objects created on the DTMI, and the production of alternative examples for comparison.

Needless to say, the research of Xambó et al. (2013) is unlike the one presented in this thesis, in that theirs investigated aspects of DTMIs in music performance, rather than DTMIs as education support tools. This difference translates to a different level of detail when parsing videos, in that the present work is not concerned with the small- and large-scale effects of transient actions on a music performance, but rather with the role that the DTMI plays in supporting understanding and discussion of musical concepts.

Questionnaires

Questionnaires were administered at the beginning and at the end of each session. The pre-session questionnaires were intended to assess the previous musical experience of the participant, and their confidence in their ability to make music. The post-session questionnaires inquired about the experience of the participants during the session, their feelings of accomplishment – e.g., whether they felt that they had learned something new, or improved their previous understanding – and engagement – e.g., whether they felt concentrated and focused, or stressed and uncomfortable. Both types of questionnaires may suffer from self-reporting bias, and therefore can be trusted only to some extent. For this reason, the pre-session questionnaires were used largely as context for analysing the rest of the data, and the post-session questionnaires were considered as insight into the participants' perception of the session, and as a form of experience evaluation. Furthermore, the pre- and post-session questionnaires both explored the participants' self-confidence in their ability to make music before and after the sessions; thus the answers were used together to gauge whether participants felt that the activities had any effect on their self-confidence. Lastly, the optional comments that some participants added to their Likert scale answers were used to get a better sense of the nuances that could not be expressed in numbers. Most of the comments were found in the post-session questionnaires, in which participants were asked to rate their agreement or disagreement with several statements. Comments were purposely prompted with a simple "comments:" line, instead of using statement/question pairs such as "I enjoyed the experience / Why did you, or did you not, enjoy the experience?". This was done so that the participants could feel free to express their views (Toerien et al., 2004). Comments found in the pre-session questionnaires were mostly aimed at specifying particular circumstances – e.g., adding "in school" to the number of years of music studies, or "years ago" to the self-rating of instrument abilities.

Likert scales Most of the questions in both the pre- and post-session questionnaires were Likert items, and answers were collected on 5 levels, from 1 to 5 in all cases. The mode was considered instead of the average or the median, since these are meaningless in analysing categorical answers, such as those gathered with Likert scales (Jamieson, 2004). The mode represents the most frequently occurring value – or the most frequently given answer, in this case. Knowing the opinion of the majority of the participants is more meaningful than, for example, knowing the median of the answers. This is particularly true with categorical data such as the typical Likert agreement levels – "strongly agree", "agree", "neutral", "disagree", and "strongly disagree" – where median and average simply cannot be defined.

Lastly, Likert scales may be subject to several biases, some of which can be addressed by making questionnaires anonymous. Other biases include

- *central tendency bias*, the tendency to avoid extreme answers in order to avoid being seen as an extremist, or in the belief that stronger statements will appear later in the questionnaire;
- *acquiescence bias*, the tendency to agree with the statements as presented, or the tendency to answer in the way one thinks the researcher wishes one would answer.

These have to be addressed in other ways, for example by carefully designing the statements. In the post-session questionnaire, the statements were formulated in a strong way – e.g., "*I concentrated intensely on the task*", "*I am confident in my ability to compose original music*" – in the hope to mitigate central tendency bias on the one hand, and to elicit a strong reaction by the participant that would mitigate acquiescence.

Interviews

Interviews and discussions were a very important part of each study – with some caveats for the first study, for reasons that will be explained in chapter 4 – and therefore constituted, together with video footage, one of the main focuses of analysis. Interviews and discussions focussed on the educational content of each study, and therefore were analysed for the ways in which participants understood such content, and learned how to use it to make music. Thematic analysis was performed in a bottom-up manner in order to understand

- how the participants talked about the contents – e.g., the use of contour as a visual metaphor to describe melody, the use of similarity and contrast to describe and create narrative in melody
- how the participants developed their understanding through the sessions – e.g., the role of the DTMI as an easy way to make music, the role of tutoring, the role of group discussion, the use of the DTMI as a mediator for group discussion, and so on.

Lastly, the studies often included an informal debriefing, in which participants discussed their session with the researcher. These debriefing discussions were not always recorded formally, since they rarely included observations that were considered relevant to the studies. However, comments were sometimes recorded when they were considered to contain insights into the issues explored in the study, or useful in the development of further studies.

Worksheets

Worksheets varied in form across the studies, and were used, where appropriate, to supplement the thematic analysis of the interviews and the group discussion. In particular, the first study employed a GCSE-inspired worksheet for the artwork analysis parts, and a custom designed worksheet for the music analysis parts. The second study featured a series of increasingly complex musical exercises to be performed directly on the tabletop interface; therefore, the answers were partly recorded as application logs, and partly noted in writing. In the third study, the worksheet was a script that was used to prompt and direct the group discussion, therefore the answers were recorded on video.

Transcripts and quotes

Direct quotes are often offered as part of the analyses presented in this thesis. These quotes can come different data sources, including video transcripts, interviews, comments on the questionnaires, worksheets, notes taken by the researcher, and so on. The same comments and notes were often associated with different participants, usually because different participants commented or behaved in similar ways. Additionally, participants sometimes made comments that were not relevant to the objectives of the studies. The quotes that are given in the analyses are a selection of the entire data set, which can be found in the appendices. The selection process comprised two passes:

1. the quotes that were not relevant to the studies were discarded;
2. the remaining quotes after the previous pass were grouped based on their content, thus dealing with duplicates.

Duplicates were identified based on their meaning, and on the contexts in which they appeared, and this determined the way in which they are presented in this thesis. For example, terms such as "*rising*", "*climbing*", "*going up*", and "*ascending*" were recorded, grouped together, and represented using any of those terms interchangeably. On the other hand, sometimes longer quotes were grouped together, but it was chosen to present all of them in text to offer a more nuanced picture. The following is an example of longer quotes that were grouped together, but presented in full.

- *Not really understand, but refine my previous conceptions might have been.*
- *Understand is probably too strong, but at least it helped being more aware of it.*
- *A bit better, but I might need further discussion.*
- *Better, but not fully.*

In this way, the quotes that are presented in the analyses are both concise and representative of the data.

Application logs

Log files were recorded by the tabletop applications that were developed for the studies, and included information such as events – e.g., interactions with the tabletop application – and artefacts – e.g., the music that participants composed – among other study-specific information, as discussed in chapters 4 to 6. These logs were machine-processed in order to turn them into human-readable output. The output was analysed, for example by looking for patterns of interaction, and matching the musical artefacts with the participants' explanations, among other aspects described later. Patterns produced by touch interaction – i.e., finger strokes – were particularly used in the first study for identifying the use of visual shapes while composing music, while the musical artefacts themselves were more important for the second and third studies, where they were part of the content analysis aimed at evaluating the educational outcomes of the sessions – i.e., the development of participants' understanding of the musical concepts that were being discussed.

3.2.3. Ethical issues

Research with human participants means having to deal with the possibility, however unlikely, that harm of any nature may come to them. In this research, three broad categories of reasons for concern were identified: issues with physical and psychological harm, issues with the identification of participants through collected and processed data, and issues with intellectual property.

Physical and psychological harm Physical and psychological harm may come in many different ways. For example, participants can trip on loose cables, fall, and get hurt, or they can come into contact with electricity, or the activities to be performed during a session may cause undue stress to participants. During the course of this research, such matters were discussed at length, and reasonable precautions were taken in order to minimise risks associated with physical injuries. Regarding psychological harm, it was decided to adhere to the code of ethics and conduct published by the British Psychological Society. In particular, chapter 4, section 1.3, comma xii ("Avoid intentional deception") was considered for Study 1, in which the purpose of the study could not be fully disclosed before the end of the session. However, it was considered that the study did not include forms of deceptions that would fall under this classification.

Anonymity In the case of issues with the identification of participants through data collected or elaborated, participants may suffer harm if their opinions or actions are unintentionally divulged. Data collection was designed to minimise this risk by filing the consent forms separately from the questionnaires and other materials that a participant produced. However, an issue with video recordings remains, in that participants had to be concealed as much as possible without compromising the ability of the researchers to analyse their behaviour. Therefore, video files were kept on secure storage provided by the university, and were accessed only for the purpose of analysis, and only by authorised persons. In case stills were necessary to be used in publications or presentations, where adequate concealment was unfeasible, participants were told that they would be asked for further consent. Participants were informed that the principles of the Data Protection Act in effect in the UK were considered, and that their data were treated accordingly.

Intellectual property In the case of issues with intellectual property, harm may again come in may different ways. In particular, the possibility that participants could claim ownership of the artefacts produced during their sessions was considered in this research. There is an argument that participants own intellectual property rights over all artefacts that are produced through their input; therefore, it was decided that participants would be considered owners of such rights over the musical artefacts as processed from the logs and as they appear in the video recordings, and they were informed that such data were going to be used strictly for research purposes. Participants were informed that they were considered as owners of the IP rights over the music that they produced during the sessions. They were also informed that the principles of the Data Protection Act in effect in the UK had been considered, and that their data were treated accordingly.

Ethics review and approval The studies presented in this thesis were submitted to the Open University Human Research Ethics Committee, and received approval before they were carried out.

3.3. Pilot study

The aim of this study was two-fold: first, to investigate how musically inexperienced people would approach a music composition task using a DTMI; second, to test and fine tune the methodology for further studies. The study followed up from a previous work by Laney et al. (2010) aimed at understanding the issues arising in collaborative music-making using multi-touch surfaces. The focus of this previous work was on the engagement and interplay of novices and experts using multi-touch surfaces to perform a piece of music, first by following a pre-existing score, and subsequently by improvising.

The participants in the study conducted by Laney et al. (2010) were presented with a tabletop interface that allowed them to control four audio samples each, sixteen in total, grouped by instrument, so that each participant would be in charge of only one instrument. The findings suggest that users having different degrees of musical experience collaborated proficiently, that they enjoyed the process, and that they felt they were working as a group. However, several issues were identified. Some participants felt that there were too many rules to follow, particularly in the scored part; that there was a lack of visual feedback indicating which sounds were playing and who contributed to what at any given moment; that they could have used more than four samples; that they sometimes wished to have control over others' samples; and that communication between the participants could have been improved by having virtual voting buttons instead of physical signs that had to be raised, so that no-one was required to shift attention away from the surface.

Some of these issues were considered in developing the prototype that was used in this pilot study. For example, in order to address the users' complaint about the limited number of samples, a larger number of samples were used, compared to those used by Laney et al. (2010), and a preparation phase was also implemented, in which participants chose the audio materials they wanted to work with. Such a preparation activity was found by Truman (2008) to result in increased engagement in music composition activities. The study was also designed differently than the one by Laney et al. (2010), in that participants had to compose, rather than perform, a piece of music.

3.3.1. Prototype design

The main purpose of this prototype was to make the task of music composition accessible to musically inexperienced participants. To achieve this, a set of requirements was produced from the issues identified in the previous work. The requirements were as follows:

1. to explicitly support the preparation phase;
2. to provide adequate visual feedback to help people understand what is happening at all times;
3. to provide people with more samples to work with;
4. to relax the ownership of these samples, so all the users could influence each others' choices;
5. to improve communication among users about whether they are happy with the outcome of their efforts.

Composing a piece of music may be an intimidating task for people with little, if any, musical experience. To make this task less so, it was decided to give participants an extra-musical object – i.e., the painting painting shown in figure 3.1 – and ask them to compose music that they felt could relate to it – i.e., that could be played as background music in the room where the painting was on display, acting as a commentary to improve the audience's awareness of the painting's elements, engagement with the exhibition, and understanding of the artwork. It is entirely possible that referencing extra-musical material can make composing music more difficult for people with little musical experience, as discussed in section 5.1.1. However, since the idea is not unheard of in the educational and musical literature – as demonstrated by Russo et al. (1983) in a traditional setting, and by Truman (2008) in a more technology-oriented setting – it was considered a relatively safe task. To further minimise the risk that participants might find the task difficult to approach, an abstract painting was chosen in order to reduce possible cultural biases when dealing with concrete scenes such as still lifes or portraits.

Figure 3.1. Wassily Kandinsky. *Einige Kreise*. 1926.

3.3.2. Tabletop activities

The following is an overview of the tabletop prototype and musical materials that were used in this pilot study.

Preparation phase The researcher created a set of 31 audio samples with three different instruments and one drum kit beforehand to fulfil requirement 3. The painting was analysed and interpreted by the researcher, and a set of labels to describe it was produced. The painting was interpreted as a representation of outer space, in which celestial bodies move slowly around each other, in a way reminiscent of the ancient concept of *musica universalis*, the music of the spheres. Six labels were created using this interpretation – emboldened in the following list.

Classic expresses the idea of the classical concept of *musica universalis*, but also the opposite of the abstract style of the painting. This label was purposely ambivalent to elicit discussion among the participants regarding its meaning.

Dreamy refers to the sense of floating sometimes perceived while dreaming, and to the sensation of weightlessness perceived in interstellar space.

Harmonious refers to the "harmony of the spheres", which is one of the translations used for *musica universalis*, and represents the idea of harmony often expressed using circles.

Sleepy expresses the hypnotic effect sometimes experienced while observing objects moving cyclically.

Strange refers to how abstract art is sometimes perceived, and refers to the style of the painting.

Swift expresses the opposite of the type of movement which involve the circles in the painting, and was included in the set to elicit discussion among the participants.

The audio samples were produced so that different samples could be described by one or more of the labels. For example, repetitive arpeggios played on a piano were classified as classic and harmonious, whereas single, long notes played on a synthesiser were classified as strange and dreamy. The application that supported this phase allowed the participants to use their interpretation of the painting to select the audio samples, as will be discussed in section 3.3.4. The choices made by the participants were recorded by the application, and used to configure the

Figure 3.2. The circular score interface used in the music making activity.

music making activity (requirement 1).

Music making activity The music making activity was supported by an application in which several pre-composed audio samples were placed inside a circular score (figure 3.2) that was playing in a loop. The score featured four concentric tracks, and was divided into eight sectors. The system played one sector after the other in a clockwise fashion, and audio samples placed in the four tracks of the section currently playing were played at the same time. The system also highlighted the currently playing section, therefore providing visual feedback (requirement 2).

3.3.3. Handling of participants

Participation in this study was voluntary and anonymous. Participants were persons willing to try a novel technology for music composition that required no prior musical experience; therefore, both musically experienced and inexperienced people were welcome to participate. Their background skills were assessed individually to put their contributions into context. Participants were recruited by explaining to them the content and aims of the study. If they agreed

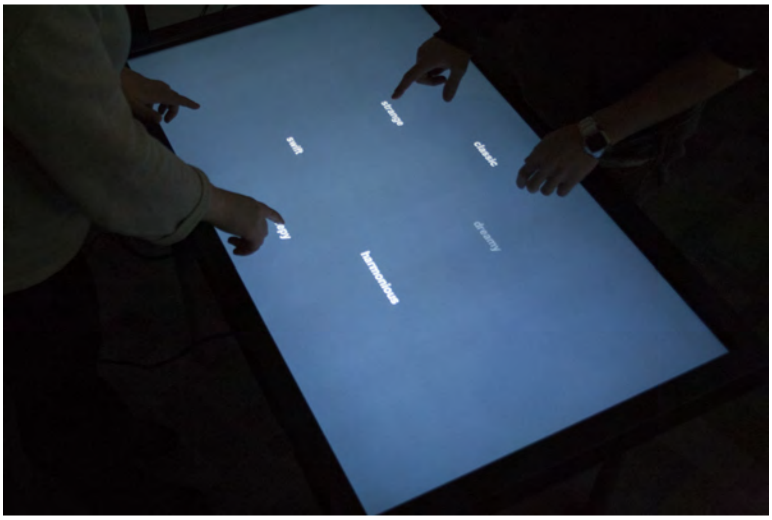


Figure 3.3. The interface used in the first part of the preparation phase.

to participate, they were asked for further consent to audio-visual recording, and they were informed that they could leave the session at any time without consequence. Lastly, they were informed that they could ask to withdraw their data after the session up until the point of anonymisation – i.e., the point when the data could no longer be traced back to them. If participants agreed to these terms, they were asked to sign the consent form that can be seen in appendix A.

3.3.4. Protocol

The following is a summary of the different phases of the sessions, and what the participants were asked to do in each of them.

Initial discussion The groups began the sessions by freely discussing the painting, and were encouraged to come up with as many ideas about it as they possibly could, eventually agreeing on one or more interpretations that they felt appropriate.

Preparation phase The discussion about the painting led participants into the preparation phase (requirement 1), aimed at reducing the set of 31 audio samples

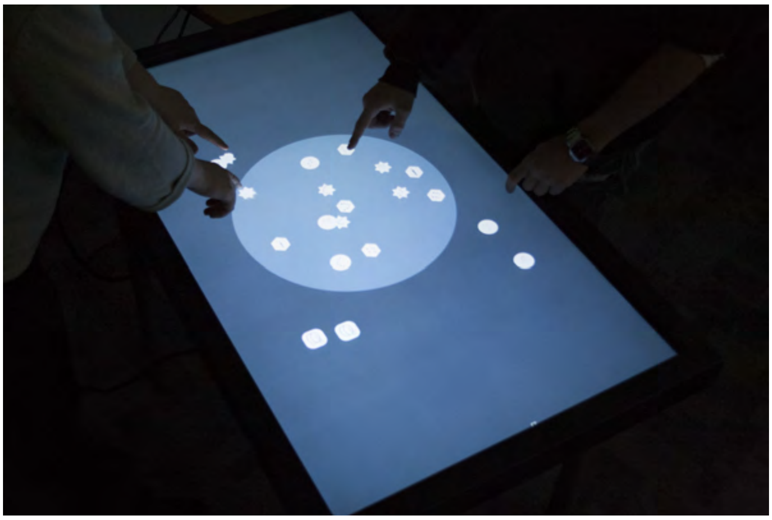


Figure 3.4. The interface used in the second part of the preparation phase.

to a more manageable size – although there was no fixed size of the resulting set, and the participants could in principle select the whole set, or an empty one. Additionally, this phase was intended to make participants familiar with the samples before they began working with them. To this end, the labels associated with the audio samples were presented on the tabletop interface (figure 3.3), and participants were asked to select those that they felt related the most with their previously agreed interpretations of the painting. Once a subset of labels was selected, the samples falling under these labels were presented to participants inside a circle, as shown in figure 3.4. Participants were instructed to listen to the samples, and were asked to exclude from the circle the samples that they did not feel appropriate for describing the painting.

Music making activity After the participants agreed on the set of audio samples that they wanted to use, they could start working on their composition. Each participant was provided with a copy of the set that they selected, and the interface presented them with a shared circular "score" onto which they could drag the samples (figure 3.2, implementing requirement 4). Once the participants felt satisfied with their work, they could confirm this by touching the centre of the score all at the same time, marking the end of the session (requirement

5).

3.3.5. Findings

Quantitative and qualitative data were collected in forms of questionnaires, video recordings of preliminary group discussion and hands-on activity on the tabletop interface, and informal post-session interviews. The full materials can be found in appendix A.

Pre-session questionnaires

The pre-session questionnaire comprised four questions, three of them regarding the participant's musical background, and one on their self-confidence in their ability to make music. Table 3.1 summarises the answers from the pre-session questionnaire that were related to the participants' perceived instrument skills and confidence in their ability to compose original music.

- Group 1 was composed of three participants: two of them declared having received formal music education for more than seven years, and one declared having received no music education, but to have played an instrument for "*a little while*".
- Group 2 was composed of three participants: two of them declared having received formal music education for at least one year, and one to have received no music education at all.
- Group 3 was composed of four participants: three of them declared having received formal or informal music education for at least six years, and one having received no music education at all.

Participants in group 2 were arguably those with the highest confidence in their ability to make music. In all the three groups, only two participants had never received any form of music education, whereas five had received music education for at least six years.

group	no	informally	formally
1	1	0	**2**
2	1	0	**2**
3	1	1	**2**
All	2	2	**6**

(a) Q1: Have you studied music?

no	one	more
0	**3**	0
1	0	**2**
1	0	**3**
2	3	**5**

(b) Q2: Do you play a musical instrument?

never	occasionally	often
1	**2**	0
2	0	1
1	1	**2**
4	3	3

(c) Q4: Have you ever composed original music?

group	1	2	3	4	5
1	1	**2**	0	0	0
2	0	**3**	0	0	0
3	0	0	1	**3**	0
All	1	**5**	1	3	0

(d) Q2.1: How would you rate your skills on your best instrument?

1	2	3	4	5
1	0	**2**	0	0
0	**3**	0	0	0
3	0	1	0	0
4	3	3	0	0

(e) Q4.1: How confident are you in your ability to compose original music?

Table 3.1. Summary of the answers to the pre-session questionnaires

Analysis of the session activities

After completing the initial questionnaire, the participants were briefed about the task. They were told that they were going to compose a piece of music that could be played as background in a room where the picture in figure 1 was on display. Table 3.2 summarises how long each group spent on each of the phases.

group	discussion	label selection	samples selection	composition
1	2' 30"	4' 35"	8' 25"	16' 20"
2	1' 55"	2' 30"	7' 5"	13' 20"
3	5' 30"	25"	7' 45"	15' 40"

Table 3.2. Time spent on each phase by each group.

Initial discussion During the initial discussion, all the participants discussed the content and aesthetics of the painting: "*it looks like a bird flying out*" (G1), "*it's colourful so it's kind of happy*" (G2), "*looks like planets, or a black hole sucking up the galaxy*" (G3). Both groups 1 and 3 tried to reach an agreement in an explicit way: "*we can vote!*" (G1), "*should we decide something at this point?*" (G3).

Preparation phase (labels) In this phase, the groups went through all the labels (figure 3.3) and argued about how these could relate to their previous interpretations. The discussion was mostly about the content and aesthetics of the painting, but two groups also discussed the specific meaning of the labels shown on the tabletop: "*if we say sleepy it doesn't necessarily mean it's not swift*" (G1), "*if you see it as art, you can say it's classic art, but if you think of music that can describe it, I don't think it's classic*" (G2). The third group completed this phase quickly, with one participant going through the labels one by one, and holding informal votes for each. Table 3.3 reports the total times each label was chosen.

label	frequency
dreamy	3
harmonious	2
sleepy	2
strange	2
classic	0
swift	0

Table 3.3. Frequency of choice of each label.

	audio samples selected	
group	after labels	after samples
1	16	11
2	18	6
3	21	12

Table 3.4. Number of samples selected by each group after each of the two parts of the preparation phases.

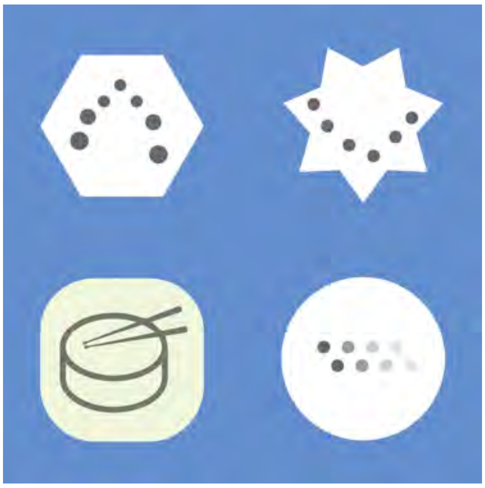


Figure 3.5. The four different shapes of the icons associated with the four different instruments. From top-left clockwise: a xylophone, a lead synthesiser, a piano, and a drumkit.

Preparation phase (audio samples) The next step, shown in figure 3.4, allowed the participants to listen to the samples that were selected in the previous step. During this phase, all the groups chose to discard some of the loops, as shown in table 3.4. This was expected, since some of the labels, like "classic" and "swift", and some of the loops were designed to relate to the picture in less obvious ways than others. In fact, table 3.3 confirms that the labels "classic" and "swift" were never selected by the participants. The discussion on the audio samples was mostly about timbre and contour, and how they related to the picture rather than to the labels: "*I don't like that because it's going down, the picture is more stable*" (G1), "*this up and down can represent the change in size of the circles*", "*shall we go for these* [synths] *just to… surprise yourself?*" (G2), "*in a sense, the picture is uneven so we may not need a constant background*" (G3). Lastly, it is worthwhile noting that the three groups began the selection work by separating the audio samples into groups according to the shape of their icons, which were associated with different instruments (figure 3.5).

Music making activity Once the participants were happy with their choices, they could start creating their musical piece (figure 3.2). In this phase, the three groups behaved rather differently from each other.

- The participants in group 1 spoke rarely. Their conversations consisted mostly of short utterances and half-sentences regarding how the application worked, rather than how they could arrange the audio loops onto the circular score. Toward the end of the session, they decided to use as many audio samples as they could and they became particularly excited, often laughing and changing each others' contributions very quickly.
- The participants in groups 2 added sounds to the composition slowly, because they wanted to "*understand how the system worked*" before starting to make music, as they said in the debriefing. They frequently discussed choices before performing them, and they often commented on the outcomes: "*we can prolong this section*", "*let's put this here as an introduction to that*", "*no it was better the other way around*", "*that kind of leads into that*", "*that's a nice progression*". Notably, one participant contributed to the music making activity by discussing ideas and alternative choices instead of directly interacting with the application.
- The participants in group 3 began by exploring the functionality of the system, similarly to the second group, but they stopped exploring and started composing after about two minutes. During this time, they asked the researcher to explain to them what section would "*start playing*". After receiving a brief explanation of this, one participant asked whether they could pause the system from "*going around*" – the answer was "no", which the participant simply acknowledged. After this initial explanation, the participants started working on the musical composition. They maintained a lively discussion, and kept trying different combinations at a sustained pace. They also tried to plan things in advance in relation to their previous discussion about the painting, in which they mentioned "*a black hole sucking up the galaxy*" – in particular, they planned to "*start quiet and add more things as it goes around*". After about 15 minutes of working on the musical composition, the participants were surprised by a sudden "*explosion*" that they were not expecting: "*that killed it!*", "*that*

was the black hole!", "*maybe it's good, unexpected, like the picture!*", "*it lures you into a false sense of security, you lay back, relax...*".

Videos were further analysed, looking for decision making, actions, and discussion. The following themes emerged from the transcripts.

Collaboration The participants in all the three groups collaborated easily by discussing their ideas together and reaching an agreement in both the initial discussion and the preparation phase. In the music composition phase, the ways in which the participants collaborated were different.

- Group 1 was largely silent while composing music. Often, a participant pointed at the screen, and uttered short comments, or asked for the opinion of the others regarding some choice that they had just made, or were about to make.
- Group 2 discussed their choices more actively, and using longer sentences than group 1. However, the discussion was sparse, and reserved for decisions which affected the broad structure of the piece of music. The following is an example of a typical conversation between two participants in group 2.
  - 1: *So, that's progressing somehow.*
  - 2: *That's quite nice, but this isn't going to work so well on its own.*
  - 1: [inaudible, adds a sample to the sector previous to the one currently playing] *as an introduction to that* [points at the sector currently playing].

  Notably, one of the participants in group 2 interacted with the tabletop far less that the other two, during the music making phase – in fact, the video of the session shows him interacting only five times. However, this participant discussed choices and ideas as much as the other two.
- Participants in group 3 held an active discussion throughout the entire music making phase, often discussing choices and commenting on each others work. The following is one example of the conversations that they carried on.

- 1: *So, if we decide this is our background for the moment we can just…*
- 2: *… put the clips… yeah.*
- 1: *It's a nice feature, but then you're limiting your choices.*
- [3 and 4 add more samples]
- 3: *So, in other words, the background doesn't have to be exactly the same all the time.*

Aesthetics All the groups discussed the aesthetics of the painting and of the music in similar ways. Participants in groups 1 and 3 repeatedly gazed at the painting during the music making activity, and participants in group 3 often commented on how well or badly some of the audio samples represented different parts of the painting – "*if we try to confront it with the picture a little bit maybe we could* [inaudible] *with the little circles and larger circles* […] *we've established that the drums are the black parts, the background, and maybe this is something that gets higher, but there's something that's higher than everything else to represent the bit that's in the middle*". On the other hand, participants in group 1 only occasionally uttered judgement values on the quality of their work, in particular in relation to the painting.

Conversely, participants in group 2, after a rather brief initial discussion of the painting, decided to focus on making a "*good piece of music*", rather than on relating it to the painting. In fact, they almost never gazed back at the painting. One could speculate that participants in group 2, having reported high confidence in their ability to make music, were more interested in making music for the sake of making music, rather than making music that referenced the painting. However, the participants did not further qualify their intention to make a "*good piece of music*", thus it is not possible to draw conclusions.

System design To different extents, all the groups devoted some time to understanding how the system worked before starting the actual work. Groups 1 and 3 spent respectively 1' 20" and 2' learning how the system worked. On the other hand, estimating how long group 2 spent on this was problematic. The participants in group 2 started by adding one or two samples to the score, and then adding more at a slow pace, eventually starting to work on their music composition. A rough estimate could be that group 2 spent between 40" and 1' 20" exploring how the system worked.

A number of comments on the system design were made by all the participants during the informal post-session discussion. For example, some participants wished that they could pause and resume playing of the score, and that they could listen to the loops while the music was paused; the ability to trigger on and off some bars in order to play or skip them was mentioned by two participants, and the ability to rearrange the bars to try different sequences was also pointed out by one participant.

In order to relate the data to the existing literature, a collection of themes inspired by the works of Hornecker et al. (2006) was used in the following analysis. Additionally, as explained earlier in this chapter, themes proposed by Bryan-Kinns et al. (2012) were used to identify elements of mutual engagement between the participants. The following section summarises the analysis under these themes – guidance regarding who proposed each specific theme is provided: themes from Hornecker et al. (2006) are marked with "H", and themes from Bryan-Kinns et al. (2012) are marked with "B".

Tangible manipulation (H) The participants could easily identify the elements of the system and associate actions such as tapping an icon and effects such as listening to the corresponding sound. However, they asked for clarifications about the circular score, in particular whether the distance from the centre had any effect, and also the lack of clarity of some visual cues caused some confusion and prompted them to ask for help.

Embodied facilitation (H) The relatively small size of the table allowed the participants to easily communicate with each other, and influence each others' actions.

Expressive representation (H) The participants were able to use the system to discuss possible alternative choices, and to record and discuss their decisions.

Mutual awareness (B) The system made contributions explicit by design, but it provided no way to identify individual contributions once they were made. This forced the participants to be aware of each other at all times, but they did not find this difficult.

Shared representations (B) Similarly, the explicit representation of the shared goal – i.e., making music, represented by the circular score on the screen – let the participants clearly identify what was happening, although some aspects could be improved with better visual cues.

Mutual modifiability (B) After a participant made a contribution by placing a sound sample on the score, the other participants could only rely on their own memories to identify individual contributions at a later stage, as the system provided no obvious cue; therefore, the contributions could be considered as equally important. However, different levels of musical experience among the participants created informal roles and hierarchies, resulting in different degrees of mutual modifiability: less experienced participants were seen making changes to actions performed by more experienced participants, whereas more experienced participants felt more comfortable applying changes to anyone's contributions. Only one participant, the one who interacted less with the interface in group 2, mentioned this in the debriefing: the other two participants asked the reason for interacting less, and the first participant stated that "*I'm not very good with music, you seemed more… expert!*". The other two groups did not discuss roles in the debriefing, therefore it is not possible to draw conclusions.

Annotation (B) All the activities prompted discussion with no need for the system to provide explicit affordances to promote it.

The theme **Spatial Interaction** from Hornecker (2008) was not included because not relevant to this study.

	1	**2**	**3**	**4**	**5**
Q1.1	0	0	1	**5**	4
.2	0	0	2	**5**	3
.3	**4**	3	2	0	1
.4	0	1	1	**5**	3
.5	0	1	2	**6**	1
Q2	0	**4**	**4**	1	1
Q3	0	**5**	2	2	1

Table 3.5. Summary of the answers to the post-session questionnaires of all the participants.

Post-session questionnaires

After completing the composition task, the participants were asked to complete another questionnaire about how they felt during the music-making task and how they felt about making music after trying the prototype. The post-session questionnaire was composed of the following seven questions.

- Q1.
  1. I felt we operated as a team
  2. I felt part of a collaborative process
  3. I felt that accomplishing the task was difficult
  4. I enjoyed composing a piece of music
  5. I concentrated intensely on the task
- Q2. How confident are you in your ability to compose original music?
- Q3. How much would you consider trying to compose original music in the future?

Table 3.5 summarises the answers to the post-session questionnaires and the results are promising. The participants were quite satisfied with the level of participation (Q1.1 and Q1.2) and only one participant rated the difficulty five, whereas none of the others rated it more than three (Q1.3). Statements Q1.4 and Q1.5 corroborate the levels of engagement and enjoyment observed in the video recordings and reported in the debriefing discussions. It is also interesting to note that the confidence in the participants' ability to compose music was generally raised, although closer inspection of individual cases showed that two participants reported the same scores that they reported in the pre-session questionnaire, in both Q2 and Q3. The remaining eight participants reported an increase of one or more points out of five in at least one of the two questions.

Limitations

One of the purposes of this study was to assess the usability of the prototype, therefore the results concerning engagement, enjoyment and ease of use have to be considered in the right perspective. For example, the fact that the playback could not be paused and resumed put some unnecessary pressure on the participants while they were still trying to figure out how the system worked. Another limitation of this study was the self-reported assessments of musicianship and self-confidence in the composition task. There are two aspects of this problem: first, no baseline was formally estimated, meaning that the participants could under or overestimate themselves; second, the participants could report data based on what they thought the researchers would want to hear. These are all possible outcomes, but establishing a baseline and carefully triangulating questionnaires' answers with interviews and observations as objectively as possible is essential to establish a more realistic perspective.

Notes for improvement

The study provided a useful assessment of the prototype's usability and identified users' requirements and expectations. The participants suggested some improvements and features that they would have expected to find.

Multi-touch and graspable interfaces, due to their strong connection with the physical world, may benefit from the inclusion of conceptual metaphors at the design stage, as suggested by Wilkie et al. (2009). Conceptual metaphors are ways to understand ideas in a certain domain in terms of another domain, for example understanding intensity in terms of direction – as in "turn the volume up". In this context, conceptual metaphors can provide invaluable insight on how to design both the virtual and physical components of a multi-touch and graspable interface.

Considering these observations, and those made by the participants in the pilot study, a new prototype was developed to fit the needs of study 1 that was being designed along with it. This new prototype proved more than adequate for the first study presented in chapter 4, and was minimally adapted for the other two that are described in chapters 5 and 6.

3.3.6. Lessons learned

This pilot study provided invaluable insight into the effectiveness of the different analysis techniques that were chosen.

The core data source, and analysis target, was arguably video. Understanding group dynamics would have been difficult without the possibility of watching the footage several times, each time focussing on a different facet. Needless to say, this approach takes a considerable amount of time. With a rough total of three hours of footage, the transcription process took around six hours. Annotating for tabletop interaction took around four and a half hours total. Annotating for group behaviour was done more quickly, as at that point a certain familiarity with the footage was achieved, therefore bringing the grand total to roughly fourteen hours of work for three hours of footage, including cumulative time for re-checking specific spots.

Producing transcripts was clearly the most time-consuming step. However, it provided a chance to go through the footage at a slow pace, therefore acquiring familiarity with it, which in turn helped to speed up the subsequent steps. Annotating for tabletop interaction was also rather time-consuming. This comprised all the actions – such as touches, strokes, and so on – that participants performed on the tabletop. In hindsight, this type of annotation contributed in a limited way to the analysis. Comparatively, dialogue transcripts and annotations of group interaction contributed in a more significant way to the analysis, therefore it safe to say that automated parsing of time-stamped application logs could have saved a considerable amount of time – about a third, in this case – and produced results of comparable quality that would need to be double checked with actual footage only in dubious cases.

Questionnaires were effective up to a certain point. As discussed in section 3.2.2, they can be subject to several types of self-reporting bias, and this has to be considered when analysing them. Nonetheless they provided insight into participants' background and musical experience, and into their experience during the session, that would otherwise have been difficult to collect in a structured way.

Informal post-session chats were also helpful in capturing nuances and further comments that could not be expressed in the questionnaires. This led to the decision to adopt an open commenting policy in the questionnaires used in the rest of the studies, meaning encouraging participants to add comments to each and every question in the questionnaires, where they felt that their structured answer was not capturing their exact point of view.

3.4. A tabletop musical application

A new prototype was designed alongside the first study presented in this thesis, and therefore some of the choices closely relate to its research question. However, after the first study was completed, it was clear that the interface had potential for exploring concepts other than contour, and therefore two more studies were designed around it, with no significant development time added. The first study will be explained in detail in chapter 4, but for the sake of exposition, it is useful to point out now that it concerned learning and applying the concept of *contour* – or *melodic motion* – to reasoning about, and creating, melody.

3.4.1. Software as a research tool

While it is true that many musical tabletop applications already exist, very few of them present the specialised kind of affordances that this research required, and even these few were impractical to use, for reasons such as monetary cost, incompatibility with the available hardware, and lack of the required features.

Bespoke software can also be designed tightly around a research question, thus limiting unrelated features that may distract users. The user interface can be kept minimal, so that users can learn it quickly, making it suitable for short experimental sessions. Developers have control over familiarity, meaning that they can decide whether the software can look like something users may have seen before or not, and they can accommodate different experience levels and different types of users. Lastly, bespoke software presents the opportunity for deep and detailed logging (Fencott, 2012), which can be invaluable in complementing analysis (Xambó, 2015). Developing bespoke software can indeed be costly – it definitely costs time. However, the benefits in terms of research certainly outweigh the costs, at least in the case of this research, and therefore it was decided to proceed in this way.

3.4.2. Hardware platform

An E-VOLUCE 46" Multi-touch Monitor was used, connected to an Apple Mac mini, as the hardware part of the prototype. The screen came fitted with an infrared frame by PQ Labs for detecting up to 6 independent touch points. The screen did not support any sort of fiduciary markers, therefore preventing the use of physical objects, as seen in other similar systems such as the Reactable. The screen came also fitted with an anti-glare coating, and had a resolution of 1920 x 1080. The Mac mini was chosen for its small form factor, making it ideal for concealed installation, and for the ability to run all the three major operating systems: Mac OS X, Microsoft Windows, and Linux. Mac OS X was ultimately used, being a popular OS in the creative software development community, with many actively supported development libraries and environments, and an enthusiast support community.

3.4.3. Software platform

The software part of the prototype was developed mostly in C++, using Cinder as a backbone, a library for creative coding, Pure Data for the MIDI output part, and GarageBand for Mac for the audio output part. Cinder was chosen over OpenFrameworks, the major alternative creative coding library, because of its approach towards dependencies: instead of committing to specific versions

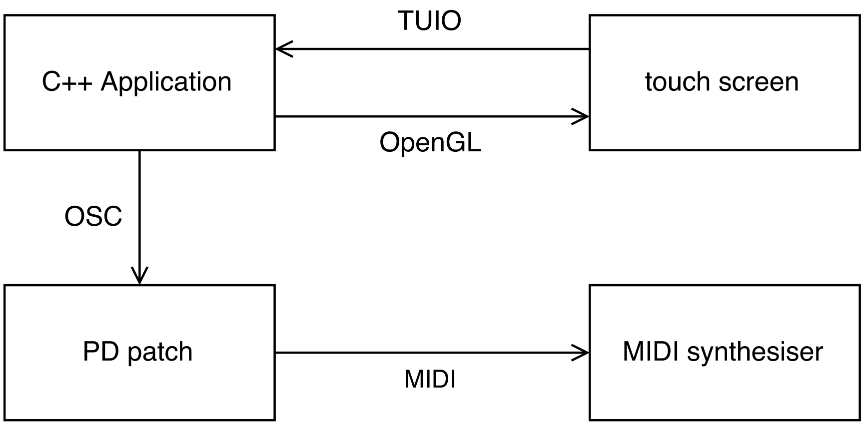


Figure 3.6. The block diagram of the DTMI described in section 3.4.

bundled together with the library, Cinder takes advantage of a platform's native capabilities whenever it is possible, and bundles as few third-party libraries as possible. According to Cinder's developers, "*this makes for much lighter, faster applications, and means Cinder apps get free performance, security and capability upgrades whenever the operating system does*"[1].

Architecture

A block diagram of the full system is shown in figure 3.6. The C++ application receives information about touch points using the TUIO protocol (Kaltenbrunner et al., 2005), an "*open framework that defines a common protocol and API for tangible multitouch surfaces*"[2] that uses OSC as a communication protocol. This is the same approach adopted by other DTMIs, including the Reactable. The C++ application, which is the core of the prototype, uses touch events – such as touch down, touch moved, touch ended – as input. A simple gesture recognition system had to be developed due to a lack of practical existing alternatives that were compatible with Cinder. The application itself uses OSC to communicate with a Pure Data patch in order to produce sound. The OSC messages contain the rough equivalent of MIDI Note On and Note Off messages, specifying the

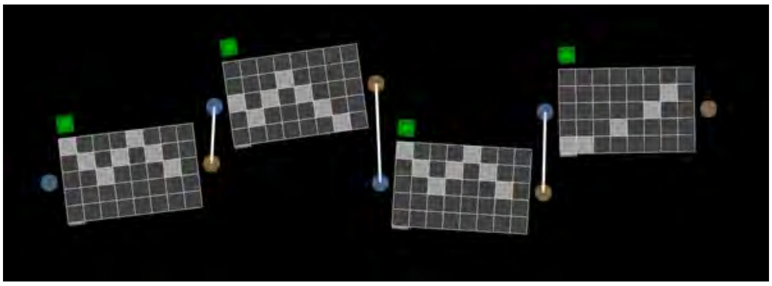
[1]http://libcinder.org/about/ (accessed on 14 September 2015)
[2]http://www.tuio.org/ (accessed on 14 September 2015)

pitch of the notes to be triggered. The PD patch receives such information and dispatches the corresponding MIDI message. This mechanism was implemented to make the C++ code less dependent on OS specific MIDI libraries, and therefore more flexible in integrating different audio technologies, and ultimately more easily portable. The MIDI messages dispatched by the PD patch can be caught by any software or hardware synthesiser. During the course of this research, GarageBand for Mac was used to play the MIDI notes, generated by the tabletop application, using the Grand Piano software instrument provided with GarageBand.

The application

A screenshot of the application is shown in figure 3.7a. The interface was designed so that a number of participants could work around the table. The design is loosely based on a timeline metaphor, but does not map spatial layout to any musical parameter other than time and pitch. In fact, it has been suggested that avoiding spatial mapping may be beneficial in tabletop applications, as it allows dynamic coupling between participants through a territorial use of the work space (Klügel et al., 2011). For example, in the pilot study participants had to ask whether the distance from the centre meant anything.

A block like one of those in figure 3.7a represents a short melody, and can be considered equivalent to a bar in a traditional music score. A block is oriented towards the user when the *play* button is at the top left corner, and this orientation will be assumed for the rest of the thesis when discussing such blocks. The rectangular grid inside a block represents the notes in the melody, where the horizontal axis represents time, and the vertical axis represents pitch. This layout was inspired by the piano roll editing mode that is commonly used in many software sequencers, therefore the design was assumed to be already functional, and it was also easy to use with a multi-touch screen. Furthermore, the design was regarded as appropriate to provide a link between the aural and visual representations of music – i.e., to make contour explicitly visible, since this was the objective of the study for which the prototype was developed. Lastly,



(a) A screenshot of the new prototype.

(b) The staff representation of the melody shown above screenshot, assuming a C major pentatonic scale between C_4 and A_4.

Figure 3.7.

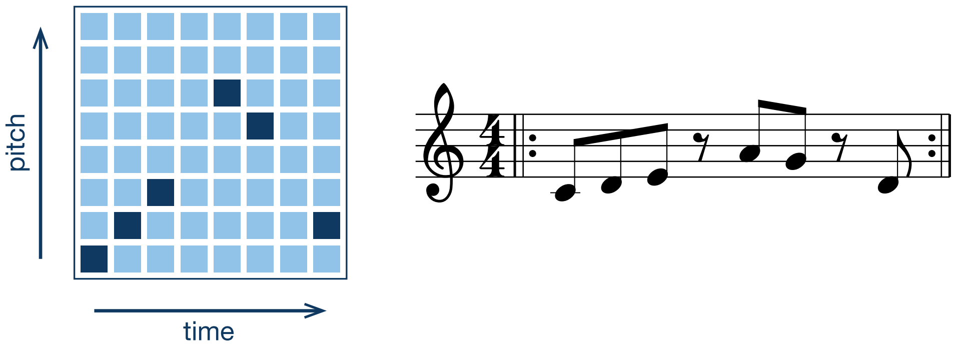


Figure 3.8. Left: block representation, extracted from the applications' logs, used in chapters 5 and 6. Right: staff representation of the block on the left, assuming a C major diatonic scale between C_4 and C_5.

a block can be played by tapping on its play button, which then turns into a stop button that can itself be tapped again to stop playback. A block continues playing in a loop until it is stopped. Figure 3.8 shows the representation of the blocks used in the analyses presented in this thesis, and how these representations are read.

When two or more blocks are connected, they form a sequence in which the block order is determined by which outlets are connected: if block A's right-hand outlet is connected to block B's left-hand outlet, then block A precedes block B. If a block's left-hand outlet has no connection, this block is the first of its sequence. If a block's right-hand outlet has no connection, this block is the last of its sequence. If a block is in a sequence, when that block is finished, the next in line starts playing. When the last block of a sequence is finished, the first block of the sequence starts playing, and continues until playback is stopped by a user. By these rules, every isolated block is a one-block long sequence. Connections can be formed by drawing a line beginning on the right-hand outlet of one block, and ending on the left-hand outlet of a different block; connections can be broken by drawing a line intersecting the connection. The sequences can be dynamically reconfigured, and insertion of a sequence between two blocks of an existing sequence is supported.

In the example shown in figure 3.7a, the blocks were configured to represent bars in 4/4 time, and divided in eight slots, thus allowing quavers to be used. The blocks show only five rows, and that is because they were configured to use a pentatonic scale. This scale was chosen because it allows beginners to compose arbitrarily long melodies on a single base chord. If we assume a C major pentatonic scale, and a time granularity of quavers, the sequence shown in figure 3.7a can be interpreted as the score shown in figure 3.7b.

Further details on configurations will be given in chapters 4, 5, and 6.

4 A study of melodic contour

This first exploratory study was aimed at providing insight into the issues of designing a DTMI-supported learning session around a simple musical notion. For this, a DTMI was developed around the notion of *contour*, and a learning session was designed so that the DTMI could be used as a support tool for novices to explore the use of contour in melody, and to compose music.

4.1. Melodic contour

Getting musically inexperienced people to compose music that can be meaningful for them is a hard problem. One of the ways in which this can be made easier is by using extra-musical material as a support for the musical concepts being explored. The pilot study presented in section 3.3 provided evidence that using an abstract painting can help novices to discuss and compose music. Among the aims of the study presented in this chapter was understanding how a DTMI-supported music learning session can be designed.

Melodic contour is an intuitive conceptual metaphor that offers a visual correlate of the shapes in the aural domain of music, and yet it is a fundamental concept for both the beginner and the advanced musician, in that it provides a way of describing melody in intuitive terms using a simplified vocabulary. Nettl (1956) explains that, "*in order to determine the contour of a melodic movement, one simply puts on paper a single line that corresponds roughly to the rising and falling melody of the song*". In this study, a subset of the vocabulary proposed by Nettl (1956) was used. In particular, the following terms were used in the sessions, along with corresponding visual and musical shapes.

- Ascending: pitch rising.
- Descending: pitch falling.
- Undulating: equal alternating movement of pitch up and down.
- Pendulum: extreme undulation over a large range, using large intervals.
- Arc: pitch ascending and then descending (upward arc), or descending and then ascending (downward arc).

Contour was chosen for this study because it is a fundamental musical notion that is intuitive enough for novices to grasp and use, thus allowing the study to be designed with the right balance between the need to evaluate the DTMI's usability, and the need to understand the issues involved in designing a DTMI-supported learning session. The DTMI that was used in this study was presented in section 3.4, and was designed to emphasise the relationship between melodic motion and visual shapes. The intention was to allow participants to comprehend the relationship while using the system, and that this would allow them to confidently discuss melody using the appropriate language. In order to make participants comfortable with the notion of contour as a visual concept, they were asked to base their compositions on a painting, which can be seen in figure 4.1.

4.2. Research question

The idea behind this study was to understand how a DTMI that requires no musical training to be used could help users to acquire the notion of contour, and to use this to make music, in a stress-free, enjoyable, and meaningful experience. To understand the issues involved in designing a learning session based on such a DTMI, this study was designed to answer the research question posed in chapter 1. In particular, this study explored the concept of melodic contour, and addressed the following sub-questions.

SQ 1.1. Does the DTMI provide adequate support for people to understand melodic contour to the point of being able to use it to compose a melody that relates to a painting?

Figure 4.1. Wassily Kandinsky. *Arch and Point*. 1923.

SQ 1.2. Does the DTMI pose usability challenges that hinder the ability of its users to learn about melodic contour and to compose music?

SQ 1.3. Does the DTMI provide an enjoyable experience, favouring concentration and learning, or does it create undue stress?

It is important to stress that this was an exploratory study. The role of DTMIs in music education has been sparsely researched, and so this study was intended to be a step toward more systematic research in the field (Dillenbourg et al., 2011).

4.2.1. Forms of evidence

The following list is derived from the research question and sub-questions stated above.

Familiarity with contour (SQ 1)

Being familiar with contour means not only being familiar with the association between a musical shape and its visual counterpart, but also being able to express this association consistently, using a vocabulary that is shared with, and understandable by, both musicians and non-musicians. To gather evidence of this, two analysis tasks and one music composition task were designed. The following is a brief overview of the tasks in relation to the development of a familiarity with contour. The outcomes of each task was analysed using thematic analysis to produce evidence of the development of a familiarity with contour. Further details on thematic analysis can be found in sections 3.2.2 and 4.4 Further details on the tasks introduced here are given in section 4.3.1.

Music analysis task The participants had to analyse the “movement” of three pre-recorded melodies, and they provided their answers on a provided worksheet. The task was repeated after the music composition task in order to see whether and how the experience in the session had any effect on their interpretation of melodic movement. This was considered to provide part of the evidence of whether the participants realised the meaning of melodic “movement” in terms of contour.

Painting analysis task The participants had to analyse a painting, using a GCSE-inspired worksheet on which they noted their answers. The painting was chosen because it contained geometric forms that could be interpreted as contour shapes. The analysis task was repeated after the music composition task in order to see whether and how their experience in the session had any effect on their interpretation of the painting. This was considered to provide part of the evidence of whether the participants could identify musical shapes in the visual shapes.

Music composition task The participants were asked to compose a melody that, in their opinion, could provide a meaningful commentary to the painting. The participants’ work on their musical compositions was recorded on video.

After they finished working, they were asked to describe their music, and they way they worked on it. The participants' descriptions of their work were considered to provide part of the evidence of whether the participants developed an understanding of the musical shapes of contour in relation to visual shapes, such as those present in the painting.

Usability (SQ 2)

The DTMI that was developed for this study was assessed in relation to whether and how it enabled the participants to explore and use contour to compose a melody. Videos were analysed, using thematic analysis, looking for indications that the participants had difficulties in using the system – for example, finding it hard to reach the relevant parts of the interface, to use the on-screen controls, and to compose the melodies using the interface. Further indications of difficulties were gathered from the post-session questionnaires, and from the comments that participants made in the debriefing discussions. If the DTMI provided adequate support in terms of using melodic contour, and did not interfere with the participants' ability to learn about, and use, melodic contour, then the DTMI could be considered as a viable tool for supporting the exploration of melodic contour.

Stress, enjoyment, concentration (SQ 3)

It is arguably difficult to measure stress, enjoyment, and concentration without affecting them. A range of techniques can be employed: for example, physiological indicators, such as heart rate and skin conductance, are usually regarded as objective indicators of instantaneous stress, but measuring such parameters requires, at the very least, applying sensors to the participants, a situation that may be uncomfortable for some people. Observing the occurrence of *flow* (Csikszentmihalyi, 1975) can be a less invasive alternative, although typically long and complex. Furthermore, flow is intrinsically hard to observe, as extensively discussed by Moneta (2012), thus it was decided to not use it in the course of this research. In the interest of simplicity, in this study it was decided to develop a simple post-session feedback questionnaire, comprising the following items.

Q5.1. I felt that accomplishing the task was difficult.
Q5.2. I enjoyed making music.
Q5.3. I concentrated intensely on the task.
Q5.4. I am confident in my ability to make original music.
Q5.5. I think that I will make original music in the future.

Items Q5.1 to Q5.4 cover the participants' experience in the study, and were used to provide evidence of stress, enjoyment, and concentration. In particular, item Q5.4 was compared with item Q4.1 1 – "*How confident are you in your ability to compose original music?*" – from the pre-session questionnaire, to investigate whether participating in the study had any effect on the participants' self-confidence. The complete questionnaires can be found in appendix B.

To complement the questionnaire, participants were offered a debriefing discussion, and their comments were recorded in a notebook by the researcher, if considered relevant to the study. The post-session questionnaire and the debriefing comments were used to provide evidence of stress, enjoyment, and concentration. Furthermore, verbal and non-verbal communication recorded on video were considered to provide additional evidence of this, and particularly of stress.

4.3. Study design

The participants were involved individually in one session each, in which they worked through a series of exercises designed for them to acquire the concept of melodic contour. The sessions could be of two types: guided, or unguided. In the guided sessions, the researcher, acting as a tutor, discussed melodic contour with the participant before the music composition task. In the unguided sessions no presentation of contour was offered to the participants. This was done to understand whether using the DTMI alone could allow participants to acquire the use of contour on their own, or if an explicit explanation was necessary. Further details on the presentation of contour are given in section 4.3.1. Participants were assigned to the guided or unguided session randomly.

4.3.1. Protocol

Figure 4.2 shows a flowchart of the study's sessions. Information regarding the content of the study, particularly that it was about learning melodic contour – was withheld from the participants until the end of the session – or until halfway through, for the participants in the guided sessions. This was done to avoid the possibility that participants could read up on contour in advance of their sessions, so that their unfamiliarity with the concept could be reasonably assumed.

The participants were informed that, although the session was designed to last between 30 and 45 minutes, they could take up as much, or as little, time as they liked, and also interrupt the session at any time without consequences.

Session activities

The following is a detailed description of a typical session. All the materials used in the sessions are available in appendix B.

Demographics questionnaire At the beginning of the session, demographic data was collected. This inquired about whether, how, and for how long participants had studied music; whether they had ever played a musical instrument; whether they had ever tried to make original music; and how confident they were in their ability to do so. As explained in section 4.3.2, recruiting participants from the population available on the university campus meant that not all were necessarily musically inexperienced. Therefore, their answers and performance in the sessions could have been influenced by this. For this reason, the answers to the demographics questionnaire were used to inform the analysis of the worksheets relating to the music and picture analysis tasks, as well as the music composition task, which are described in the following sections.

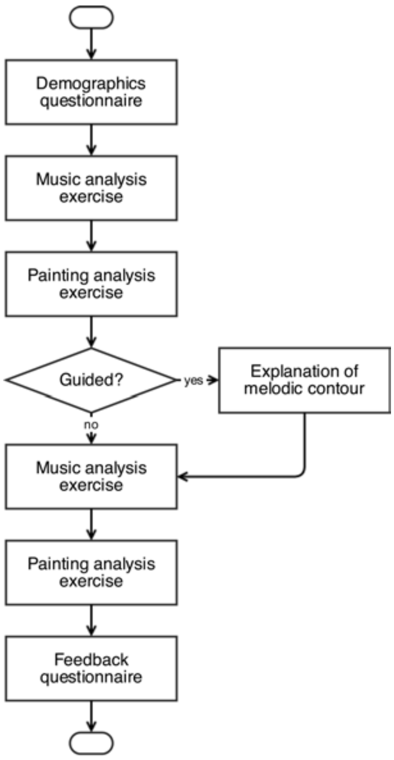


Figure 4.2. Flowchart of the sessions.

Music analysis task The first exercise of the session was a simple music analysis exercise in which participants were asked to listen to three melodies, short excerpts from "Ah! vous dirai-je maman", "Frère Jacques", and "Bunessan", and to answer two questions for each melody, using a worksheet that was provided to them. The first question was on the structure of the melody – the number of sections – and the second asked to describe the "movement" in each section. The somewhat vague term "movement" was used deliberately to encourage participants to interpret it in their own terms. In fact, using more specific terms, such as "rise and fall", could have been leading as to what they were expected to say. Participants were reassured that there were no right or wrong answers, and that participants could answer the question in any way they wanted.

Painting analysis task In this exercise, participants were asked to comment on a given painting in their own terms and according to their own intuition, and to record their comments in a GCSE-inspired worksheet (BBC Bitesize, 2015). An abstract painting (figure 4.1) was chosen with the same rationale as for the pilot study – avoiding cultural biases – and additionally to present certain geometric features that could be related to melodic shapes, and therefore described in terms of melodic contour.

Introduction to contour Participants in the guided sessions were given an explanation of contour by the researcher. Contour shapes were presented as sketches on a whiteboard (figure 4.3), and as corresponding pre-recorded short musical examples. The shapes were those described by (Nettl, 1956) and listed in section 4.1. In addition, participants were asked to think about extra-musical analogies to contour shapes, such as visually similar concrete objects – stairways, bridges, and waves – as well as other concepts and ideas – such as climbing, falling, repeating, and so on. This was done to engage them in a discussion of contour in terms that were familiar to them. The whiteboard was left visible to the participants as a reference during the music making exercise.

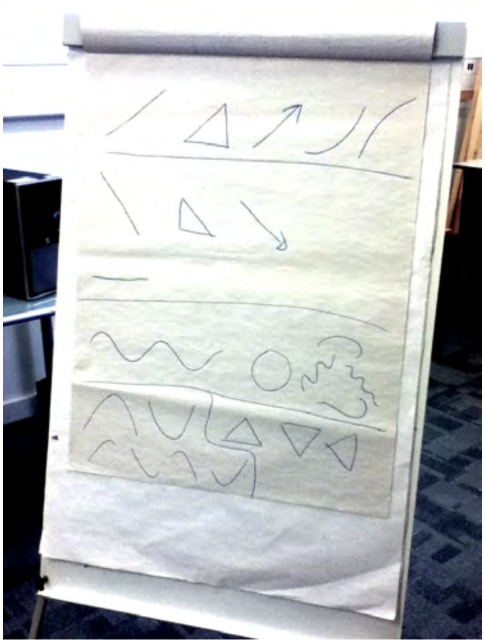


Figure 4.3. The whiteboard used during the guided sessions.

Music composition task In this exercise, participants were asked to imagine that the painting was on display in a room, and to use the DTMI to compose a piece of music that, in their opinion, could be played in a loop along with the painting, with the aim of accompanying and enhancing the visitors' experience by providing them with an additional interpretation of the painting in a non-visual medium. At this point, the video recording was started, and the researcher left the participant alone, informing them that there would be no further interaction until they finished working on the music – unless they needed help with the DTMI.

Two configurations of the DTMI were used in this exercises – a modular one, and a non-modular one. Participants were assigned to one configuration or the other randomly. This was done as part of the usability assessment of the DTMI, and to see whether the two different configurations had different impacts on the ways in which participants worked. Figure 4.4 shows the DTMI in the two configurations. The modular configuration is described in detail in section 3.4, so the following is a brief description of how it was configured for the study. Each block was considered equivalent to two 4/4 bar, and had a temporal granularity of quavers. The scale was an F suspended pentatonic (F, G, $A^\sharp$, C, $D^\sharp$), from F_3 to F_5, equal for all the blocks. In the non-modular configuration, a single, large block was all that the participants could use, and no new blocks could be created. In this case, the block was equivalent to four 4/4 bars, and the scale was the same as in the modular configuration, but this time from F_2 to F_6. The block in the non-modular configuration was made longer in time to make up for being unable to create longer sequences by concatenation. It was also made wider in pitch to maintain a similar aspect ratio to that of the smaller blocks, and of the screen.

Music analysis task The same music analysis exercise that was performed earlier was repeated identically after the music making exercise, reassuring participants once again that there were no right or wrong answers, and encouraging them to answer honestly according to their interpretation of the melodies. This exercise was repeated in order to see what effects, if any at all, the session had on participants. In particular, this re-iteration of the exercise aimed at seeing whether and how the participants changed their interpretation of the melodies, in terms of sectioning and description of contour, after performing the painting analysis and the music composition exercises.

Painting analysis task The same painting analysis exercise that was performed earlier was repeated identically after the new music analysis exercise. Participants were encouraged to annotate the worksheet if they felt that their perception of the painting had changed after participating in the session. This exercise was repeated to see whether participating in the session had any effect on the participants' interpretation of the painting. Participants were once again encouraged to answer according to their interpretation.

Debriefing and post-session questionnaire After the sessions, participants were offered an explanation of the session, and this provided a chance for them to reflect on their work in light of the exercises they had just performed. This turned into an informal discussion about the session, and the participants' impressions and remarks were recorded. Lastly, an appreciation questionnaire was given to participants fill in, according to their experience in the study. This questionnaire inquired about the perceived difficulty of accomplishing the music composition task, whether and how much participants enjoyed the experience and concentrated on the task, whether they were now more or less confident in their ability to make original music, and whether they thought they would attempt such activity in the future. The full questionnaire, as well as the worksheets used in the session, can be found in appendix B.

4.3.2. Handling of participants

Participation in this study was voluntary, anonymous, and involved only one participant per session. Participants were persons with any level of musical experience who were willing to improve their music appreciation skills. The background skills of the participants were assessed individually through a self-evaluation questionnaire in order to provide some context when analysing their sessions. Despite the fact that participants with no musical experience would have been preferable – as this would have made it easier to evaluate the DTMI's viability as an educational tool – obtaining a reasonable sample size was prioritised at the expense of obtaining uniformly inexperienced participants. It was instead decided to consider as a "beginner" anyone who had never received music education, or that had for two or fewer years, as this circumstance was consistently confirmed by the participants to coincide with compulsory music classes in school, which many attended several years in the past. All the participants were recruited among people working on the university campus, and were of diverse nationalities. Therefore, although the ages of the participants were not recorded, it was reasonably assumed that they were at least about 19 years old. Many school curricula around the World include some form of compulsory music education only until about the age of 14 – for example, this is the case up to Key Stage 3 of the National Curriculum in England (Department of Education, 2015). Therefore, it was assumed that those participants who declared having received music education in school, had not done so for at least 5 years. Furthermore, since the curricula can vary across different countries, these participants were considered to be at least as competent as someone who received music education up to the level of Key Stage 1 (Department of Education, 2015).

The only information about the study that was disclosed to the participants before their sessions was that it was about making music using a novel digital multi-touch interface. Melodic contour was not mentioned until the end of the session – or until the mid-session discussion, for the participants in the guided session – as discussed previously.

4.4. Methodology

The methodology used in this study was largely based on the general one described in chapter 3. This section explains how that methodology was implemented for this study, and how each technique was used to provide the evidence listed in the previous section.

4.4.1. Video recordings

Only the music composition task was video-recorded. It was considered that this was the only exercise that needed to be video-recorded, since all the other exercises were performed using worksheets. Video recordings were analysed primarily to provide a record of the interactions of the participants with the DTMI (SQs 1 and 2), and evidence of stress, enjoyment, and concentration (SQ 3). Additionally, videos provided a record of the music that the participants composed.

4.4.2. Feedback questionnaire

Comparing items Q4.1 and Q5.4 (see appendix B) presents an issue, since the statements are formulated a bit differently. Q4.1 – "*How confident are you in your ability to compose original music?*" – asked to express the answer writing a number between 1 and 5; Q5.4 – "*I am confident in my ability to make original* *music*" – asked to check one of five possible boxes from 1 to 5. Because of this difference, comparing the answers may be problematic. It was however decided that, since the values were expressed in integers in both cases, a comparison could still be reasonably made. Furthermore, since the two questionnaires were printed on the two sides of the same sheet, many participants actually looked back at their previous answer, therefore it can be assumed that their answers reflected an actual variation in their confidence.

4.4.3. Thematic analysis for usability

In analysing the video recordings of the sessions for assessing the usability of the DTMI (SQ 2), only three of the themes proposed by Hornecker et al. (2006) were used for the purpose of assessing the DTMI's usability.

Tangible Manipulation (TM), to see how the participants physically interacted with the DTMI, and to see whether the DTMI afforded participants easy access to the representation of music, and allowed them to experiment with music in small steps. In particular, the following behaviours were observed.

- **Gestures**: editing notes, starting and stopping playback, creating new blocks, dragging blocks, connecting multiple blocks (the last three only where appropriate).
- **Configurations**: forming sequences of blocks (where appropriate).

Embodied Facilitation (EF), to see how the physical and virtual set-ups affected the ability of the participants to interact with the system, and how they build on the participants' experiences and skills in order to provide access to the musical information. In particular, the following aspects were observed.

- **Physical affordances**: the physical dimensions of the tabletop in relation to the participant.
- **Virtual affordances**: editing notes, starting and stopping playback, creating new blocks, dragging blocks, connecting multiple blocks (the

last three only where appropriate).

Expressive Representation (**ER**), to see whether the DTMI, through the visual representation of melody, afforded participants a way of discussing melodic contour. In particular, the following aspects were observed.

Contour: use of shapes recognisable from the painting, use of contour vocabulary to describe melody.

The theme **Spatial Interaction (SI)** is concerned with how participants use the surrounding space in interacting with the system, and how the system is configured spatially. Given that the system is a horizontal multi-touch screen that users interact with by standing close to it, theme SI was not considered separately because of limited interest. There is however an overlap with theme EF – particularly in the sub-themes visibility (SI, "*can everybody see what's happening and follow the visual references?*") and access points (EF, "*can all users see what is going on and get their hands on the central objects of interest?*") – and therefore EF was modified to include this.

4.4.4. Thematic analysis for familiarity with contour

Familiarity with contour was analysed by looking at the descriptions of the melodies in the music analysis exercises, and at the strategies employed by the participants to compose music based on the painting.

Music analysis (**MA**), to see whether the participants' descriptions of melody changed between iterations. The following aspects were observed.

Contour: use of the vocabulary proposed by Nettl (1956), use of sketches relating to the vocabulary.

Variation: whether the participants changed their descriptions in the second iteration of the exercise compared to the first.

Composition strategies (**CS**), to see how the participants interpreted the painting through music. The following aspects were observed.

Visual elements: the use of shapes and spatial organisation.

Artistic intention: the use of personal interpretation, mood, and message.

4.5. Findings

Twenty participants volunteered for this study. This made it possible to assign exactly half of them to the guided session, and half of them to the unguided session. In each of these two groups, five participants per group were assigned to work with the modular configuration of the DTMI, and the other five with the non-modular configuration.

4.5.1. Demographics

The demographic data collected with the pre-session questionnaire are summarised in table 4.2. Eight participants had not studied music, or had done so for two or fewer years (Q1.1, mean = 0.63 years, sd = 0.74 years) and therefore were considered beginners according to the criteria explained in section 4.3.2. Of the remaining twelve participants, ten had studied music for 10 or fewer years, one for 20 years, and one for 47 years, therefore twelve participants were considered non-beginners (table 4.1a). It is clear from the data that not only was the group of participants composed of fewer beginners than non-beginners, but also that the non-beginners were, on average, quite expert. Even if we only consider the ten non-beginners that had studied music for at most 10 years, their average duration of studies was 6.8 years. However, six of these twelve non-beginners reported having no confidence (one out of five) in their ability to compose original music, while five scored this two out of five, and only one of the non-beginners reported a confidence of three out of five. This is positive, since among the objectives of this study was to get people to compose original music. Therefore, the issue of experience was considered for these participants in relation to their acquisition of the concept of contour, but the non-beginners were appraised equally to the beginners in relation to their use of contour in describing a painting with music.

Fifteen participants stated that they currently played, or had played in the past, at least one musical instrument, although some specified that that was "*years ago*". Overall, the participants' self-reported skills on their own instrument, on a scale from 1 to 5, was quite low (Q2.1, mode = 1).

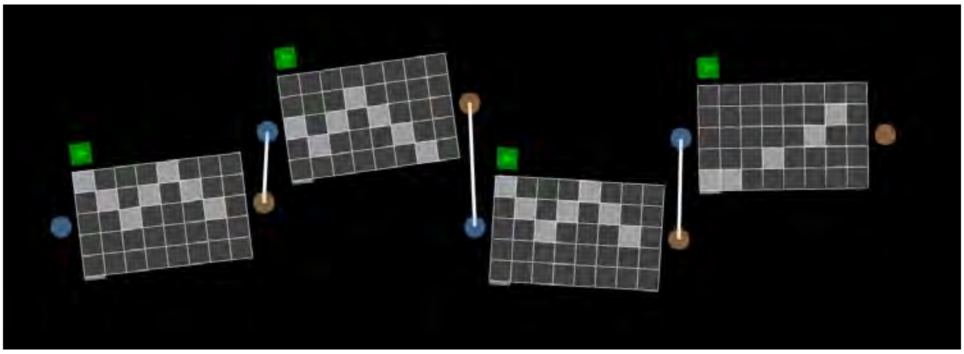
years	**participants**
$\leq$ **2**	8
3 ÷ 10	10
$\geq$ **11**	2

(a) Duration of music studies (including none)

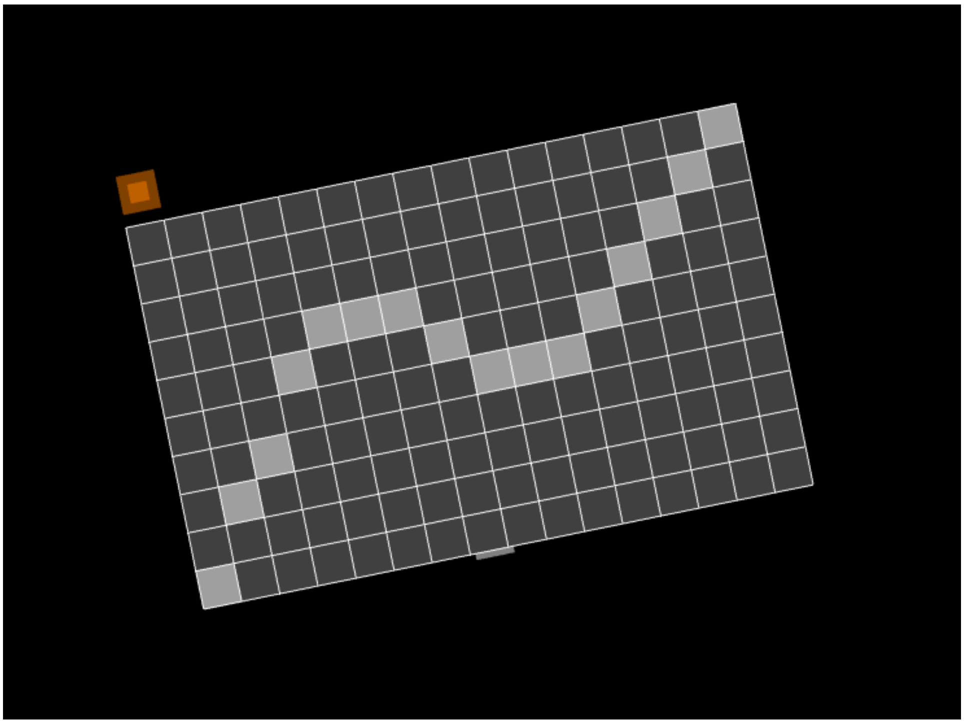
	participants
beginners	8
non-beginners	12
total	20

(b) Breakdown of the participants

Table 4.1.



(a) Multiple blocks configuration



(b) Single block configuration

Figure 4.4. The two different configurations of the DTMI used in this study – multiple blocks above, single block below.

	no	**informally**	**formally**
beginners	**4**	3	1
non-beginners	0	0	**12**
total	4	3	**13**

(a) Q1: Have you studied music?

no	**one**	**more**
6	2	0
1	**6**	5
7	**8**	5

(b) Q2: Do you play a musical instrument?

never	**occasionally**	**often**
7	1	0
6	5	1
13	6	1

(c) Q4: Have you ever composed original music?

	1	**2**	**3**	**4**	**5**
beginners	**8**	0	0	0	0
n-beginners	5	0	**6**	1	0
total	**13**	0	6	1	0

(d) Q2.1: How would you rate your skills on your best instrument?

1	**2**	**3**	**4**	**5**
7	0	0	1	0
8	3	0	1	0
15	3	0	2	0

(e) Q4.1: How confident are you in your ability to compose original music?

Table 4.2. Summary of the answers to the demographics questionnaires

Thirteen participants said that they had never tried to compose original music before (Q4), and seven of these were among those considered beginners. Overall, the participants' confidence in their ability to compose original music was quite low, with eighteen participants declaring confidence levels of 2 or less. This was encouraging since it meant that it was reasonable to investigate how effective the DTMI was in assisting people who think that they cannot compose music.

Question 3 asked the age at which participants started studying music, if they had. However, this question was marked as optional, due to its sensitive nature, and only two participants answered, therefore it was decided to ignore it in the following analysis. It was also decided to not include this question in the subsequent studies.

4.5.2. Feedback questionnaires

Table 4.3 summarises the participants' self-assessment regarding their experience in the study. This section reports on the findings from the feedback questionnaire presented in section 4.2.1.

Stress and enjoyment (SQ 3)

Participants found the task relatively easy to perform, with fourteen participants disagreeing, or strongly disagreeing, with statement Q5.1. Five of the six participants who instead felt neutral toward the statement, or agreed with it, were among the non-beginners, and the remaining one, a beginner, had indicated a confidence of 1 in their ability to make original music. This was not entirely surprising, as it is possible that a person with some experience in music might find it difficult to perform a task that was designed for novices who were assumed to have very little familiarity with music making. It is however worthwhile noting at this point that participants were asked to consider only the music making exercise as the "task", in answering the question. Eighteen participants stated that they enjoyed making music (Q5.2, mode = "agree"), and that they concentrated intensely on the task (Q5.3, mode = "agree"). This is quite a positive result, as it suggests that the DTMI offered an enjoyable music making experience to participants of all levels of experience.

Self-confidence (SQ 3)

Eighteen participants reported low confidence in their ability to make original music before the session (Q4.1 < 3, see table 4.2), and fifteen reported a low confidence after the session (Q5.4 < 3). Furthermore, only 7 participants stated that they tried composing original music before participating in the session (see Q4 in table 4.2), while 12 participants reported to be at least somewhat likely (Q5.5 > 1) to try composing original music in the future. This is a reasonably positive result: it is true that the numbers do not look particularly exciting in terms of boosting self-confidence and likelihood of trying to compose music in the future, but it is also true that they do not show, overall, degrading self-confidence and outlook. This not particularly exciting result was expected to some extent, since both the DTMI and the study were designed with novices in mind, therefore it was possibly too simplistic to inspire someone who might have been looking for a more challenging tool. It is worthwhile noting that only two participants reported high confidence (Q4.1 > 3) before the session.

4.5.3. Usability analysis (SQ 2)

The prototype was designed to be *intuitively usable*, meaning that a person should be able to approach it and start using it for its intended purpose in a short time. The participants were video recorded during the entire time in which they used the DTMI, thus it was possible to measure the time that they spent learning to use the DTMI. Six participants spent some time explicitly learning how to use the DTMI (mean = 58 s, sd = 47 s, rounded), while the others immediately started working, testing and learning the system as they progressed through the task. Of the 6 participants that devoted some time to familiarising themselves with the DTMI, only two spent about as much as two minutes on this. Whether it happened through an explicit exploratory phase, or through working on the task, this is evidence that the prototype supports *lightweight interaction* (TM) – meaning that the users can proceed in small,

	1	**2**	**3**	**4**	**5**
beginners	**5**	2	1	0	0
non-beginners	**5**	2	4	1	0
total	**10**	4	5	1	0

(a) Q5.1: I felt that accomplishing the task was difficult.

1	**2**	**3**	**4**	**5**
0	1	0	**6**	1
0	0	1	**6**	5
0	1	1	**12**	6

(b) Q5.2: I enjoyed making music.

	1	**2**	**3**	**4**	**5**
beginners	0	1	0	**4**	3
non-beginners	0	0	1	**9**	2
total	0	1	1	**11**	5

(c) Q5.3: I concentrated intensely on the task.

1	**2**	**3**	**4**	**5**
4	2	1	0	1
4	**5**	2	0	1
8	7	3	0	2

(d) Q5.4: I am confident in my ability to make original music.

	1	**2**	**3**	**4**	**5**
beginners	**3**	2	0	1	2
non-beginners	**5**	2	3	0	2
total	**8**	4	3	1	4

(e) Q5.5: I think that I will make original music in the future.

Table 4.3. Answers to the feedback questionnaires

experimental steps, and quickly learn the basics by virtue of the rapid feedback that the prototype provides.

Participants using the non-modular configuration of the DTMI were given almost no introduction to the system. Videos shows participants touching the screen with their fingers shortly after seeing the large on-screen grid. Touching the grid showed them that they could turn on and off squares, and many went for the "play" button. It is not clear from the videos whether the participants had realised that the squares represented musical notes before they touched the play button. However, the videos show that the participants were not surprised when the DTMI made the mapping explicit by playing the notes in correspondence with the moving play-head. Only one participant asked the researcher for a demonstration of the system. The fact that the vast majority of the participants assigned to the non-modular configuration grasped the use of the interface in a relatively short time suggests that seeing the large grid on screen was enough to draw their attention, and to provide a hook to start exploring.

Participants using the modular configuration of the DTMI were instead given a basic guided demonstration, in which the researcher prompted them to perform some actions – e.g., "touch the screen with your finger for a second", resulting in a small block to appear on screen, or "draw a line inside the block", resulting in some of the squares in the block to light up – and left them to work on their own as soon as they looked autonomous. Videos show that, save for a few occasional incidents, participants were hardly ever surprised by the relation between their actions and the effects on the prototype. However, participants using multiple blocks had some initial difficulty moving blocks around the interface – an action that requires dragging the blocks with two fingers – but quickly found a way of dealing with the problem. Some participants understood that the action required only two fingers to be performed, some resorted to dragging with any number of fingers. The gesture recognition system used in the DTMI was robust enough to deal with the situation by considering anything more than one touch points on a block as a dragging gesture. The prototype presented room for improvement, but participants could work through their task with only a few minor incidents. In particular, all the participants in the modular configuration found it difficult, sometimes to the point of frustration, to connect two blocks to form a longer melody. Analysis of the application logs suggested that they were drawing the connection gesture too quickly and imprecisely for the small size of the connection outlets. This was rectified in the version used for studies 2 and 3, by enlarging the invisible active areas of the outlets. The other issue that all the participants had was when editing the blocks. The way in which the touch-sensitive surface was built created a gap between the glass panel and the LCD screen, therefore a visual misalignment occurred between the positions of the fingers on the glass, and the position of the corresponding cursors on the screen. This sometimes resulted in difficulties in operating the small controls, such as turning on and off the right notes, or touching the play/stop buttons. The issue with the play/stop button was addressed similarly to the one with the connection outlets – i.e., by enlarging the invisible active area instead of the visible icons. However, enlarging the note squares inside the blocks would have resulted in larger blocks, thus limiting further the number of blocks that could be created in the modular configuration.

In summary, the participants grasped the functionalities of the DTMI quickly, and with limited external instructions. This can be considered evidence that the DTMI provides sufficient *isomorphic effect* (TM) to participants, and clear *access points* (EF), so that they can easily identify its affordances, and quickly understand how to use them. Moreover, participants interacted with the touch-screen in a way that revealed their familiarity with the multi-touch technology, for example by performing gestures such as dragging, pinching, and scribbling. The fact that the prototype was programmed to recognise these gestures, and particularly that scribbling was one of the ways to create music, can be seen as evidence that the prototype provided a *tailored representation* (EF), meaning that the interface built on the participants' experience, and that, by reacting in a familiar way, it invited them to interact with it.

4.5.4. Thematic analysis (SQ 1)

In this section, the sessions will be analysed using the themes previously identified in order to gather evidence to answer the research question in relation to the acquisition and use of melodic contour.

Music analysis exercise

Despite the vague term "movement" used in the worksheet, only four participants asked for a clarification, and two of them were beginners. The remaining sixteen participants went by their own interpretation, as they were explicitly asked to do. A less vague explanation was offered to those who requested it, but this was still deliberately vague in order to not influence the answers. Generally, in the explanation, the researcher mentioned the "movement of the melody in time", but also made it clear to the participants that the term "movement" was used vaguely in order to encourage them to use their interpretation.

The worksheets used in this iteration of the music analysis task show that fifteen participants interpreted pitch changes as up-down movement. For example, they used words such as "*up*", "*down*", "*rising*", and "*falling*", although contour-related terms were not always used for describing all the sections within the same worksheet. In fact, terms that cannot be directly related to contour were sometimes used – e.g., "*sequenced*", "*meandering*", "*waltzing feel*", and so on. Furthermore, the descriptions were not always in words either. In fact, five participants used sketches as, or in addition to, their answers; two of them did so only in the second iteration of the exercise; one participant used an approximate music notation in the first iteration, and sketched contour shapes in the second iteration of the exercise. It is worth noting that, at the point of the first iteration, participants in the guided sessions were not yet involved in a discussion of contour.

Table 4.4 offers a summary of how the interpretations of melodic "motion" of participants in the music analysis exercise changed before and after the session, grouped by the type of session in which they were involved. Both the number of sections and the nature of the descriptions of movement were considered

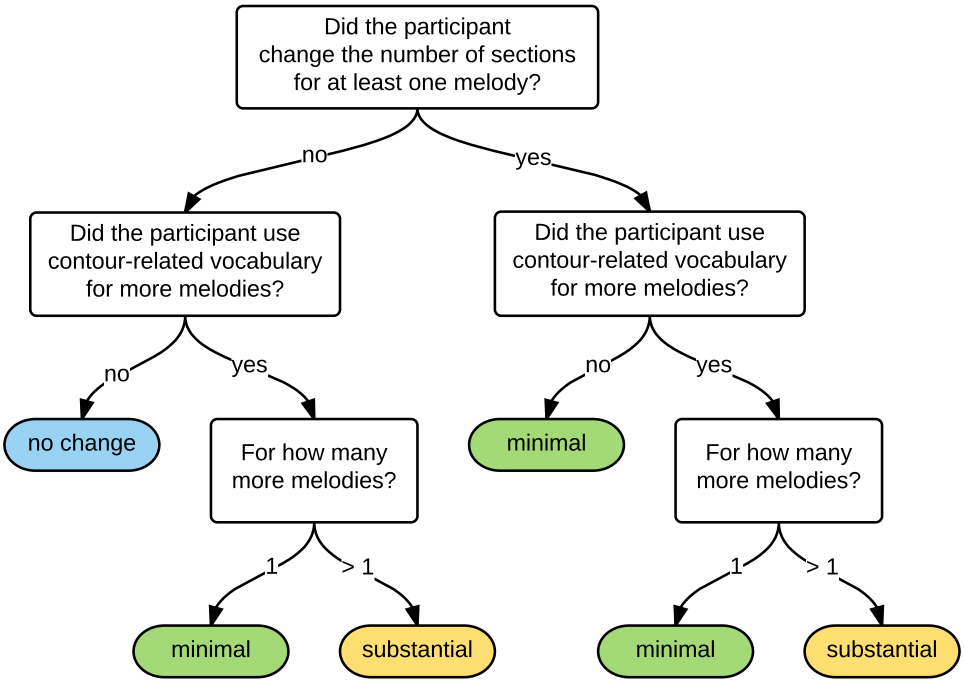
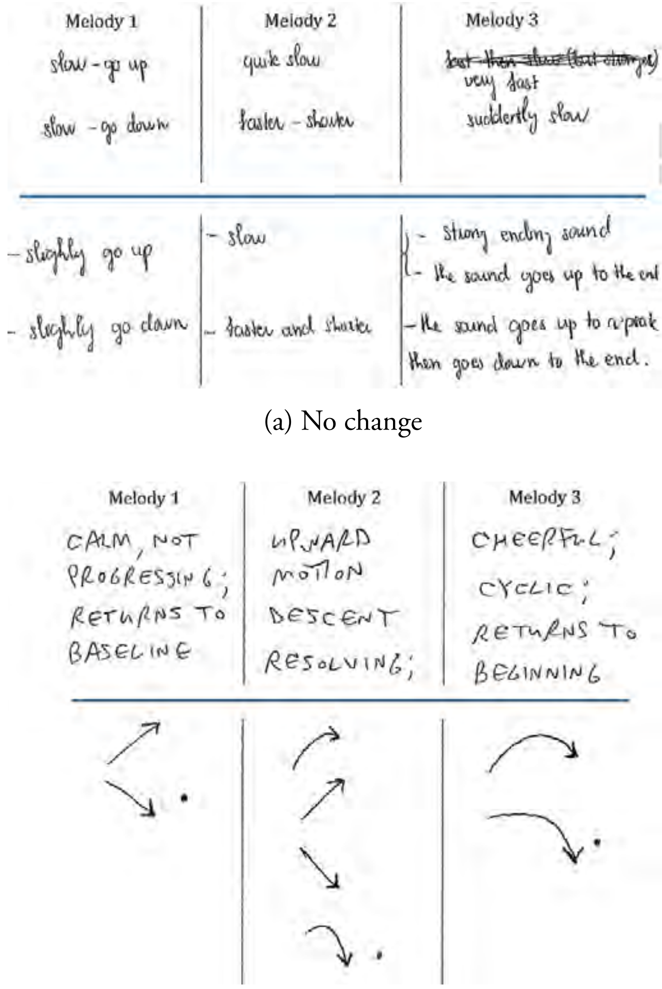


Figure 4.5. Decision tree for judging changes in the music analysis task.

	none	**minimal**	**substantial**
guided	1	4	**5**
unguided	**5**	4	1
total	6	**8**	6

Table 4.4. Summary of how participants changed their musical interpretations of contour.



(a) No change

(b) Substantial change

Figure 4.6. Examples of music analysis worksheets comparing the first (top halves) and second (bottom halves) iterations.

when evaluating variations between the first and second iterations of the exercise. Variations were considered "minimal" or "substantial" based on the decision tree shown in figure 4.5. A change in the description was considered when the participants substituted non-contour related terminology with contour related terminology – i.e., using terms such as "up/down", "ascending/rising", "descending/falling", or sketches of contour shapes. As shown in table 4.4, more substantial variations happened for participants in the guided sessions, as it was reasonable to expect as an effect of discussing contour with them.

However, it is also interesting to look at the specific ways in which the participants changed their descriptions after the music making task. In analysing this, an improvement in the quality of the descriptions of movement was considered to be a change towards the use of contour-related terminology, or of sketches of contour shapes. Figure 4.6 shows two examples. The descriptions of movement given by two participants who were assigned to unguided sessions were found to be less specific, in relation to the use of contour-related terminology, after the music making exercise than they were before. In both cases, the participants initially described the movement with a contour-related vocabulary – such as "going up/upward", "going down/downward", and so on – while in the second iteration they used non-relevant terms – such as "progress", "echo", "similar", "change", and so on. Of the remaining eight participants in the unguided sessions, two produced descriptions of slightly better qualitymore specific descriptions – they used contour-related terminology and sketches of contour shapes – while six showed no change at all. On the other hand, the descriptions of participants in the guided sessions improved in quality in five cases, and remained equal in the other five cases. It is worthwhile noting that, of the five cases that were considered to have improved substantially, four participants described movement in a variety of ways in the first iteration of the exercise, and used sketches of contour figures in the second iteration. This was likely an effect of the materials used during the discussion, and in particular of the whiteboard, but it is nonetheless a significant result, in that it shows that the intervention of a tutor served to induce the use of a specific vocabulary, and to convey the meaning of contour as a visual metaphor for music.

In summary, 14 out of 20 participants improved their answers in the music analysis task. Participants that were offered a discussion of contour demonstrated having understood that contour has a specific vocabulary, and could use it consistently with the way in which it was discussed. This means two things: first, that the prototype has the potential to help people to intuitively realise that there is a connection between music and its contour shapes; second, that when the concept of contour was made explicit by explaining it, people were more likely to use a specific vocabulary and were confident in using it, as summarised by table 4.4. These two observation can be seen as evidence, perhaps unsurprising, that discussing a subject explicitly with a figure perceived as competent – i.e., a tutor, a teacher – helps understanding the subject quickly and with confidencequick and confident understanding.

Strategies for composing music

Fifteen participants spent between approximately 5 and 15 minutes working on the music making exercise. Three participants spent less than 5 minutes and two spent over 15 minutes, with one of these two working for over 30 minutes. Furthermore, 19 participants composed several different melodies before ending the session, either by making progressive changes to their work, or by repeatedly starting from scratch. Participants using the non-modular configuration of the DTMI spent most of their time making changes to their work before, as opposed to repeatedly starting clearing the interface and starting from scratch.

Two main strategies for composition emerged from analysing the videos, particularly from the ways in which participants explained the relation between their work and the painting:

visual: participants who adopted this strategy worked by taking visual elements of the painting – i.e., shapes – and turning them into musical equivalents, thus composing music that visually related to the painting;

interpretative: participants who adopted this strategy used their interpretation of the painting – expressed through the painting analysis worksheet – to compose music that they associated with elements of their interpretation. Such elements included the feeling feeling that the painting gave induced in them, mood that they perceived from the painting, what they thought that the artist intended to represent, and so on.

During the debriefing, it emerged that all the participants tended to use one of these strategies predominantly, occasionally using the other when they felt it was appropriate or necessary to do so in order to express their intention.

Among the participants that primarily adopted the interpretative strategy, a widespread preference for science and science fiction themes emerged: 14 participants interpreted the painting as a representation of space travel, or of a planetary system. The following quotes come from the painting analysis worksheets of some of the participants who adopted the interpretative strategy.

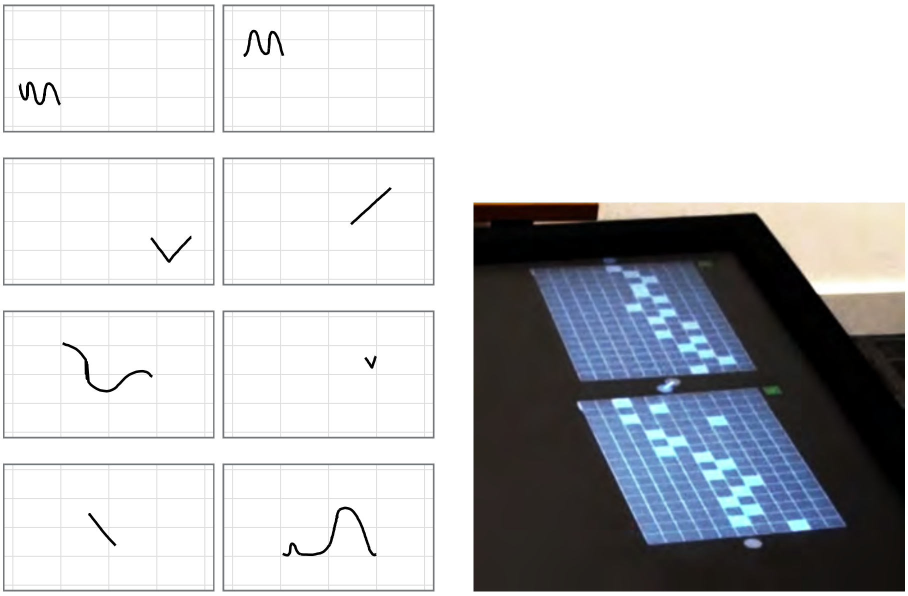
- *To me it represents space travel*
- *A solar system perhaps, with the blue shape representing a spaceship*
- *Space! Sci-fi! Feels like a rocket flying through space, passing planets and asteroids, and bits of space junk.*
- *The regular(ish) shapes and simple colours convey science/engineering type environment*
- *Also get a feeling of mathematics and science, trigonometry, geometrics"*

Four participants identified in the painting elements of order and chaos, sometimes in contrast with each other, and sometimes giving structure to the image.

- *The author may have wanted to express the tension between order and chaos?*
- *The order is added by the diagonal line through the centre*
- *I see ordered geometric forms* [...] *Objects are organised around the diagonal axis and seem to be dynamically moving to the bottom right corner*
- *Chaos – order*

Among the participants who gave these interpretations, the musical compositions were of different types. For example, the participants that related the painting to space and science fiction themes often explained their works as reminiscent of movie soundtracks from the so-called "classic" era – between the '50s and the '60s. The following are some quotes taken from the explanations given by some of these participants.

- *I used all those high notes, but sparse, and with some low... they give it this eerie feeling, like from the Space Odyssey.*
- *Here there is a series of low notes, like a spaceship sneaking behind, and here it lands, and all the robots come out with guns and all.*



(a) (b)

Figure 4.7. Some examples of the shapes that the participants used.

- *I think there's a tension in the picture, but also a feeling of events flowing. I made* [music] *like that, there is some business down here, like danger! But up there, stuff carries on, like life.*
- *The picture looked peaceful and calm to me, in the background, but with chaos and movement in the foreground. So first there are these two blocks here, they are slow and calm. Then there is, like, an explosion, a line goes down, like the one in the painting. Then I wanted to have more calm blocks, but the music loops, so I guess… it works anyway.*
- *The blocks here and here* [beginning and end] *are all nasty and crazy, that's all the danger of outer space! But in the middle* [two blocks] *you have this steady single note, like you floating.*

The four participants who identified neither of these themes, however, did not identify any theme in particular beyond what was suggested in the first of the two questions of the worksheet – i.e., forms, colours, spatial organisation, and so on.

Videos, complemented by application logs, show that most of the participants that associated the picture with order, geometry, and mathematics, created music with short, repeating, and clearly identifiable patterns. Such patterns were, for example, short ramps or small arcs, sometimes composed of as little as three notes and repeated several times, as shown in figure 4.7. It is also worthwhile noting that, although the software was designed to be strictly monophonic, two participants using the modular configuration chose to use two parallel chains of three modules each, and played them simultaneously, thus achieving polyphony. They both felt that in that way they were able to better express what they felt the picture represented – i.e., “chaos”, “superimposition”, “convergence”.

In summary, the painting proved to be a useful device for enabling participants to create music by using contour shapes, as well as to discuss music in terms of shapes. In fact, during the debriefing discussions, five participants stated that they would have been lost if the only instruction was to “make some music”. The available data provide evidence of coherent thought process linking the painting analysis task and the music making task, and video analysis confirms that the DTMI not only did not get in the way of the participants, but also provided a mean for thinking about contour as a visual metaphor, and how it can be used to relate the visual and musical domains.

Representation of contour

The DTMI was designed to highlight the connection between the aural and visual domains created by contour, so that people could recognise it and use it to discuss and make music. The data presented earlier in this section showed that the participants’ answers in the two iterations of the music analysis exercise changed after using the prototype, although to different extents. This happened regardless of the type of session, guided or unguided, to which they were assigned. On one hand, this suggests that the prototype may have played a role in this. On the other hand, the quality of the participants’ descriptions of contour improved more often in the guided sessions. This suggests that the DTMI may have played a role in enabling the participants to acquire the concept of contour. However, this also suggests that the intervention of a tutor resulted in the participants using contour to describe melody more clearly and consistently than the participants who did not receive tutoring.

Two strategies were observed in the music composition task: one was to replicate on the interface the shapes that participants were seeing in the painting; the other was to use one's interpretation of the painting to compose the piece of music. Although the participants predominantly adopted one or the other strategy, occasionally the alternative strategy was applied as well. Videos and application logs however show that, with very few occasional exceptions, all participants used shapes that they could see in the painting – e.g., straight lines, triangles and arcs, and waves (figures 4.7b and 4.7a). This alone can however not be seen as evidence that the prototype provides a concrete representation of the contour metaphor. In fact, for the *representation* to be *significant* (ER), it had to provide a way for connecting the visual and aural representations of the objects constructed by participants in a way that one can be derived from the other, and vice versa, with equal ease – i.e., it has to provide a *representation that transforms the problem* (TM) between domains. Unfortunately, this is not easy to show. On one hand, the fact that participants were not surprised when listening to the melodies that they created visually could be seen as evidence of this. On the other hand, video recordings show that many participants gestured mid-air, in ways reminiscent of contour, sometimes accompanying the gestures with singing. However, this could be due to the fact that contour is a rather intuitive conceptual metaphor, one that people are likely to come in contact with in conversations – for example, "high" and "low" notes are in fact part of common parlance in Western cultures.

In summary, we can say that the DTMI provided, to some extent, an adequate way of thinking about melody, musically and visually: this is reflected in the fact that, save for a few exceptions, participants exhibited at least an implicit understanding of the link between melody and its motion – regardless of their ability to express this using the vocabulary of contour – as we have seen in section 4.5.4. Lastly, we can also say that the DTMI supports *externalisation* (ER), meaning that it gives users an adequate representation to reason about contour, and provides a record of their thought process that can be used for reflection and further reasoning.

4.6. Discussion

Looking back at the aims of this study, we have seen evidence confirming that an appropriately designed DTMI can provide adequate affordances for musically inexperienced people to discuss and compose music in terms of contour. It is true that three in five participants in this study were far from musically inexperienced. On the other hand, the "beginners" generally improved their performance more than the "non-beginners". Furthermore, the DTMI was found to be sufficiently usable, and to provide an adequately expressive representation of contour. Therefore, we can in principle say that the DTMI provided adequate support for its users to acquire and use the concept of melodic contour (SQ 1.1). It is however critical to remember that the DTMI could only do part of the work. In fact, this study showed that the participants who discussed contour with a tutor had additional benefits in terms of acquiring confidence in using contour and its vocabulary. This suggests that, when designing technology-supported educational experiences, the tutoring element, in particular of the human kind, should be properly considered.

In terms of stress and enjoyment (SQ 1.3), videos and questionnaires were particularly helpful in identifying signs of each, as well as in mitigating observation and self-reporting biases, therefore providing a fuller picture. All participants reported enjoying working on the music making task, although some took this just to mean working on music making task itself, while others considered the creative effort involved in interpreting the painting part of the music making task. This suggests that the questionnaire could have been more specific, or that the specification of what constituted the task could have been clearer. Particularly in terms of stress, videos were effective in identifying signs of frustration and dissatisfaction. Videos confirm that frustration occasionally emerged, and that the DTMI's quirks were often the source of this (SQ 1.2). Questionnaires were of limited use in identifying a stressful experience. In hindsight, considering a low "enjoyment" score as a sign of a stressful experience was not a sufficiently clear indication. Nevertheless, based on video evidence and on debriefing discussions, no participant stated being significantly stressed or frustrated. Instead, participants consistently reported that they enjoyed working with a novel technology, sometimes more than how they enjoyed composing music with it. One participant in particular walked into the room and excitedly approached the tabletop saying "*I've always wanted to work with something like this!*"

In summary, this study provided a first positive assessment of the prototype, as well as insight on its potential beyond this study – e.g., the simplification provided by the visual representation of music, and the affordance of polyphony. This study also provided reasonable evidence that appropriately designed tools can indeed help music novices to approach a subject that they might perceive as difficult and above their abilities to tackle it. Lastly, evidence suggests that having a conversation with a tutor, someone perceived as an expert, may be necessary in order to acquire specific terminology and confidence in using it appropriately.

4.7. Conclusion

This study provided evidence to answer the questions stated at the beginning of the chapter.

SQ 1.1. Nearly all the participants demonstrated an intuitive understanding of melodic contour, and were able to compose a piece of music that, in their opinion, provided a meaningful commentary to the painting that they were asked to reference. Most of the participants to which an explanation of melodic contour was offered, used the vocabulary (Nettl, 1956) more often and confidently than the other participants. Nevertheless, some of the participants that did not receive an explanation of contour demonstrated having developed an intuitive understanding of the idea of "melodic movement" after performing the analysis and composition tasks. This suggests that the representation of melody provided by the DTMI was expressive enough to communicate the relation between musical and visual shapes.

SQ 1.2. No participants encountered significant usability issues – i.e., issues that prevented them from using the DTMI for the purpose of the study. Some minor issues were identified. In particular, many participants found it difficult to connect multiple blocks to form longer sequences, and the difficulty to activate the play/stop button. These issues were addressed before Study 2.

SQ 1.3. Nearly all the participants (18 of 20) reported that they had an enjoyable experience, and that they focussed intensely on the tasks. Some participants perceived the tasks as challenging. Neither the feedback questionnaire, nor the video recordings, suggest that the participants felt significantly stressed. However, the DTMI caused occasional nuisances, and this was captured in the video recordings.

5 A study of similarity and contrast

In this exploratory study, the notions of *similarity* and *contrast* are investigated. As discussed in Study 1, the DTMI was (i) adequate from a usability point of view, (ii) viable as a tool for learning about contour, and (iii) provided an engaging and enjoyable experience for beginners and non-beginners trying to compose music. Contour is, however, a musical concept sufficiently easy to grasp for it to be used as the basis of a study of the qualities of the DTMI. In the light of the findings from Study 1 presented in chapter 4, this study explores how the DTMI can help novices to deal with more complex notions.

5.1. Narrative as a way to compose music

It is arguably hard to get novices to compose meaningful music, while at the same time affording them a safe playground in which they can practise notions of music theory and composition. It is entirely possible to assign exercises requiring them to compose just a few bars, showing mastery of a certain notion – e.g., the use of melodic contour, the ability to use a certain harmonic progression, and so on. However, there is the possibility that this type of exercise may not be appealing to all novices. In fact, those who are not fully motivated from the beginning may be at risk of giving up an activity that they might have taken up expecting to enjoy it (Costa-Giomi et al., 2005).

Fortunately, a music composition exercise can be designed in other ways, and these can be critical in setting expectations, and retaining students' motivation when facing difficulties. One example is given by Russo et al. (1983), as the opening of chapter 1.

> *Imagine that you have been captured by the Lorac, a warlike tribe ruled by Edrevol, who will spare your life only if you please him with the music you write for the Imperial Flute.*

Russo then proceeds to list rules and suggestions – e.g., the student can only use four given tones, all the bars must have the same given rhythmic figure, the student may occasionally repeat some bars "*to unify* [their] *melody and to give it shape*", and so on. In this way, Russo argues, the student can focus on certain details, such as "*the expressive possibilities of each tone in relation to the other tones*". There are two key elements to this exercise:

1. it is framed as a fantasy situation in which the student's life depends on composing a piece of music;
2. it imposes strict constraints so that the student can focus on specific aspects of music making.

This type of framing is, however, only one way in which a music composition exercise can draw on familiar experiences, and channel them towards the exploration of the unfamiliar domain of music by creating a motivating challenge.

Referencing extra-musical elements can be a useful device when asking novices to compose music. The use of familiar extra-musical concepts can provide a starting point to direct the discussion of musical concepts: by creating associations between the musical and the extra-musical domains, novices have a chance of creating their own understanding of the musical concepts in terms of extra-musical objects and associations that they may be already familiar with. For example, studies conducted by Truman (2008) showed that children who could use visual metaphors to represent music were more engaged in a music composition task than those children who were instead given an abstract representation of music. In particular, the children in the former group spent longer creating their compositions, and tried more alternative combinations of the musical materials. However, Truman (2008) and Russo et al. (1983) used extra-musical elements in a non-musical way. Another way in which such elements can appear in music is through narration.

5.1.1. Narrative in music

Whether and how music can constitute some form of narrative is controversial, and yet something that many composers have exploited in several ways, particularly in Western music.

Narrative has been argued to exist at several levels in music. It is sometimes assumed that, because languages possess both syntax and semantics, and because syntax can be shown to exist in music (Lerdahl et al., 1983), semantics must exist somewhere in music too. In fact, it has been speculated that some primitive humans communicated in a way that we might consider musical (Mithen, 2005). While some attempts have been made to identify semantics, and therefore narrative, in particular aspects of Western tonal music – e.g., in the harmonic implications of blues and jazz chords (Steedman, 1996) – it seems more reasonable to think that, if semantics exists, it does so at an "*absolute (untranslatable) perceptual level*" (Wiggins et al., 2010), rather than at a level that refers to the physical world, as language does. This implies that the interpretation of narrative in music is a highly subjective endeavour, and it is fair to say that, without additional guidance, or particular musical devices, it is generally unlikely that two listeners would interpret the same piece of music in exactly the same way. Nevertheless, this has not stopped musicians from using music to reference extra-musical material in metaphorical ways.

One example of narrative in music – or rather, of music that comprises narration – is provided by Opera and Musical Theatre. In these forms of entertainment, the musical part is often not intended to be a narration in itself, but instead to provide support to the lyrical narration. For example, this is achieved by suggesting moods and dramatic settings to scenes, or by underlying or implying the presence of characters through specific musical themes – e.g., the folk melody "*Mo Li Hua*" that becomes the musical avatar of princess Turandot in the eponymous Puccini's opera. Ballet can be seen as a form that comprises narration in a less immediate way, but again the narration is mostly performed by the dancers, rather than the music.

Programme music is another way in which narrative can be incorporated in music. In programme music, (mostly) instrumental music is composed attempting to render musically extra-musical material, such as prose and poetry – i.e., some examples are Beethoven's "Symphony no. 6 in F major, Op. 68, *Pastoral-Sinfonie*", and Mussorgsky's "*Night on Bald Mountain*". In programme music, it is common to offer the extra-musical material to the audience in some way, for example as programme notes, or by giving a descriptive title to the musical composition, or its movements. The intention is to invite the audience to imagine the correlation of the music with the underlying narrative. In this way, composers make sure that the audience "gets" their intention, while at the same time giving them considerable freedom in constructing their own representations of the underlying narrative.

Narrative is sometimes used by professional composers as part of their works, and the way in which Russo et al. (1983) framed his first composition exercise suggests that narrative can be used to facilitate novices in composing music. In fact, this is not an entirely new idea: works such as "*Peter and the wolf*" by Sergei Prokofiev, and "*Pinocchio*" by Pierangelo Valtinoni are explicitly aimed at young audiences with the more or less explicit intent of fostering their curiosity about music, and possibly towards music studies. Furthermore, educational projects are carried on by orchestras and choirs around the World. A very recent example is "*The Monster in the Maze*" by Jonathan Dove, which was co-commissioned by the London Symphony Orchestra, the Berliner Philharmoniker, and the Aix-en-Provence Festival for their respective youth engagement projects. In projects of this type, young participants study and perform works by professional composers, and are sometimes engaged in writing parts of these works.

Getting novices to compose meaningful music is a hard problem. We have argued that DTMIs have the necessary qualities to make it easier for novices to approach music making, but this is only part of the story. It is fair to assume that being unable to play a musical instrument is not the only reason that may discourage a novice from approaching music making. Among other reasons, this thesis deals with the moment when, after a few minutes of tinkering with a musical instrument, novices wonder what they can do with that instrument that is meaningful to them. If one engages in music with the goal of becoming a musician, then the answer is simple: take lessons and practise. However, for the undecided novice, the answer may not be so simple.

Referencing extra-musical material offers novices a way of composing music that can be meaningful to them, and that can easily be used to teach musical notions in the meanwhile. The studies presented in this thesis involved composing music to describe a painting, and to suggest narrative. In the first case, the visual aspect of the painting worked well with the aim of teaching melodic contour – a visual metaphor that describes how melody moves in time. In the second case, narrative is particularly interesting in this sense because it is something that, like music, progresses through time, and can have simple or complex structures, developing more or less linearly, and so on. Narrative is also interesting for the challenge that it provides, due to its controversial status, and therefore has potential for provoking interesting reactions and outcomes.

For all these reasons, this study aims at affording novices to compose meaningful music that references extra-musical material in the form of narrative.

5.1.2. Similarity and contrast

Similarity and contrast are key concepts in Western music: similarity establishes coherence and structure within a work, and contrast adds interest (Laney et al., 2015). These two are in fact at the very foundation of most Western musical forms, in which sections repeat and change in various patterns – e.g., from sonatas in binary form to modern pop songs in thirty-two bar plus bridge form. Therefore, a good understanding of such concepts is part of the core knowledge required to understand, and compose, music. Similarity and contrast can also be used together to compose music that suggests narrative, by using similar and contrasting themes that establish a sort of musical discourse between the different parts. We will see how novices have dealt with these aspects later, but first let us briefly review the notions of similarity and contrast.

Similarity

Similarity is not a single, clearly defined property, but a complex phenomenon existing in many dimensions, and ways of characterising and measuring it have been sought for quite some time. In his seminal work, Tversky (1977) argues that there is no single way of comparing any two objects for determining their similarity. In fact, one could take any two objects, no matter how seemingly unrelated, and make some sort of similarity judgement based on some dimension or metric. For example, comparing two balls may be quite straightforward, as there are a number of dimensions and features that immediately come to mind – i.e., size, weight, roundness, material, surface texture, purpose, and so on. On the other hand, one may struggle to make a meaningful comparison between seemingly unrelated objects, such as a tennis ball and an elephant. One can certainly compare their size and weight, and perhaps their surface texture, but it would probably be a stretch to compare their need to breathe and feed, or their ability to spontaneously ambulate. Nevertheless, this reveals that one way in which we can determine similarity is by the number of dimensions, or features, that any two objects have in common. By this rationale, the more dimensions we can meaningfully compare two objects along, and the closer these objects are along these dimensions, the more similar these objects are (Tversky, 1977). However, we have yet to see what similarity may mean in music, and how we can use it in the context of this research.

Similarity in music, and particularly in melody, has been investigated extensively (Marsden, 2012), and several explanations of what makes melodies similar have been proposed. However, if we consider the argument that music is an inherently subjective experience that only exists within the listener (Wiggins et al., 2010), we have to accept that a potentially infinite number of models and measures may exist. For this reason, it helps to restrict the focus as much as possible. Study 1 dealt with the notion of melodic contour: coincidentally, contour is among the top factors in determining similarity in melody, as found by Eerola et al. (2001) and Urbano et al. (2011) among others. This makes sense if we accept that the language of contour describes melody in terms of shapes, and shapes are an important factor in determining similarities between objects and figures, as investigated by Tversky (1977).

Contrast

By contrast, ironically, *contrast* seems to have been researched to a far lesser extent than similarity (Laney et al., 2015), at least in terms of identifying features and ways of categorising it. The Oxford Encyclopedic English Dictionary defines contrast as "a juxtaposition or comparison showing striking difference". However, such a definition is unsatisfying: it is not necessarily true that two very different objects – such as an elephant and a tennis ball – are in contrast with each other – they may in fact just be different. This brings us back to the notion of dimensionality discussed for similarity, and introduces the notion of comparability: it is hard to find contrast between two objects if these cannot be compared along a meaningful number of dimensions. It is true that an elephant and a tennis ball contrast in size and shape, and it is true that one breathes and feeds, and the other does not. However, very many fewer meaningful comparisons can be reasonably made, thus it is easier to conclude that a tennis ball and an elephant are just two different things. On the other hand, an eagle and an elephant can be compared along a larger number of dimensions. For example, both breathe; both need to feed, but they have different dietary requirements; one lays eggs, the other gives birth to live offspring; one flies, the other walks; one is covered in feathers, the other has short hair; one is significantly smaller than the other. Many other comparisons can be reasonably made: depending on whether we decide to attach a judgement of contrast to any number of these comparisons, we can – or cannot – say that eagles and elephants are in contrast with each other. In light of the above, we could define contrast in a similar way as that in which Tversky (1977) defines similarity – that is, if we can judge two objects contrasting in enough reasonable dimensions, we can consider these two objects contrasting as wholes.

This characterisation of contrast is useful in terms of music, because it means that we can use the same dimensions that we use for similarity – for example, melodic contour, rhythm, mode, and so on – thus allowing us to reason about similarity and contrast together.

5.1.3. Summary

The concept of melodic contour was sufficiently intuitive for novices to grasp it, and to serve as the basis of a study of the qualities of the DTMI as a tool to support novices in learning about musical notions. Study 1 was successful in showing that an appropriately designed DTMI could support novices in exploring musical notions, as well as in assessing the usability of the DTMI itself. The question at this point, is: how does the same DTMI, which was designed for exploring monophonic melodic contour, stand up to the test of notions at a higher level of abstraction?

In this thesis, it was decided to focus on melody, particularly monophonic melody, because it is simple enough for a novice to work with, and yet powerful enough for a novice to produce music that could be meaningful for them. In particular, this study investigated the notions of melodic similarity and contrast, and their role in creating structure and narrative, because they provide an excellent opportunity for continuing the investigation of the DTMI's viability as a music education tool.

5.2. Research Question

Understanding similarity and contrast, and their role in suggesting narrative in music, is not a trivial endeavour, certainly not when undertaken by novices in the context of melody. To understand how the previously developed DTMI could help novices in such an endeavour, this study was designed to answer the research question stated in chapter 1. In particular, this study explored the role of melodic similarity and contrast in suggesting a narrative, and addressed the following sub-questions.

SQ 2.1. What are the criteria by which the participants judge similarity and contrast in melody? How do people relate the two concepts?

SQ 2.2. How do the participants understand the role of similarity and contrast in creating structure and suggesting narrative in melody? What strategies do the participants use in composing a melody that tells a story?

SQ 2.3. Does the DTMI provide adequate support for its users to discuss and understand similarity and contrast in melody?

SQ 2.4. Does the DTMI provide an enjoyable experience, favouring concentration and learning, or does it create undue stress?

It is important to stress that this was an exploratory study, as were the previous studies. The role of DTMIs in music education has been sparsely researched, and so this study was intended to be a step toward more systematic research in the field (Dillenbourg et al., 2011).

5.2.1. Forms of evidence

The following list is derived from the research question and sub-questions stated above.

Development of criteria for similarity and contrast in melody (SQ 2.1)

The researcher noted the participants' comments and observations throughout the sessions. This provided a record of the ways in which participants developed ways of thinking about melody in terms of similarity, as well as by the melodies produced while working on the exercises. The conversations between the participants and the researchers – described in section 5.3.1 – provided insight on the participants' initial definitions of similarity and contrast expressed in general terms, and identified the criteria that they used in judging these two concepts. During the course of the session, the conversation provided evidence of how the participants developed criteria for determining similarity and contrast in melody. Application logs recorded the melodies that were produced during the course of each session. This provided a record of the musical choices that the participants made. Analysing the melodies provided additional evidence of the criteria that were used, and how, in composing melodies using similarity and contrast.

Use of similarity and contrast in suggesting narrative in melody (SQ 2.2)

The participants were asked to explain their work throughout all the music composition tasks, and their answers were recorded by the researcher. This provided a record of how they used similarity and contrast in the melodies, and of how they used similarity and contrast to suggest narrative in melody. Furthermore, the participants' comments throughout the sessions were noted by the researcher. This provided additional evidence of the ways in which the participants developed a familiarity with the concepts of similarity and contrast.

DTMI as a discussion mediator and educational tool (SQ 2.3)

The researcher noted the ways in which the participants interacted with the DTMI to compose and discuss melody. In particular, the interactions with the surface and the use of the virtual objects were noted. This provided evidence of how the participants used the DTMI to explore and discuss the musical concepts. Analysing whether and how participants used the DTMI in discussing similarity and contrast, and in performing the exercises, provided evidence of the role of the DTMI as a discussion mediator.

Stress, enjoyment, and concentration (SQ 2.4)

The same feedback questionnaire used in Study 1 was used in this study, and participants were offered a debriefing discussion to complement the questionnaire and record any additional comments or insights. In addition, the researcher noted the participants' comments and non-verbal communication clues. The combination of these with the post-session questionnaires and debriefing discussions were considered evidence of how enjoyable or stressful, easy or difficult the participants perceived the sessions to be.

5.3. Study Design

Participants were involved in individual sessions, one per participant. The sessions were designed as conversations between the participant and the researcher, acting as a tutor, and mediated by the DTMI. During a typical session, the tutor prompted the participant to express their views on similarity and contrast in a general way, and progressively brought the discussion towards melody, through a series of exercises performed on the DTMI. The intention was to help the participant to relate their understanding to the context of melody.

5.3.1. Protocol

The following is a brief outline of a typical session. A rough explanation of the session and its main objectives was offered to participants before the session began.

1. **Demographic questionnaire**
2. **Discussion** on similarity and contrast guided by the researcher, acting as a tutor
3. **Listening and classification exercise**
4. **Challenge-response exercise**
5. **Fill-the-gaps exercise**
6. **Storytelling exercise**
7. **Post-session questionnaire** and (optional) debriefing

The participants were informed that, although the session was designed to last between 45 and 60 minutes, they could work for as long as they liked, and also interrupt the session at any time without consequences.

Session activities

The following is a detailed description of a typical session.

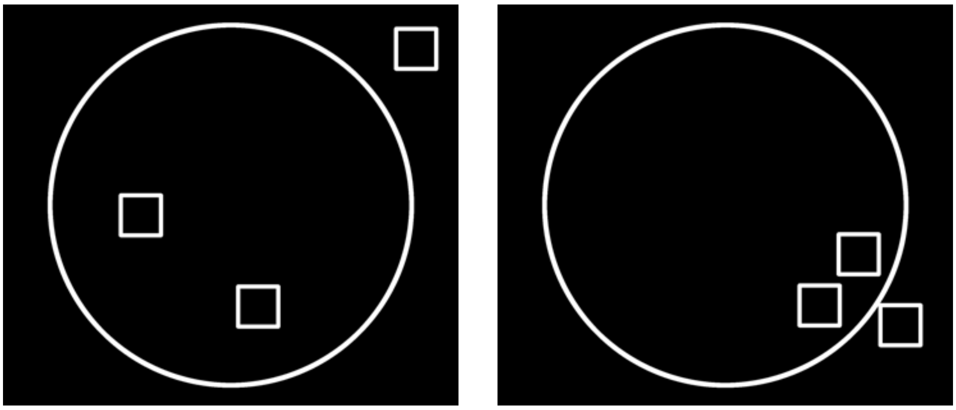
Demographics questionnaire At the beginning of the session, participants were asked to complete a questionnaire regarding their musical background, and their experience with making music. This questionnaire was identical to the one used in Study 1, and it was used in the same way in the analysis. The questionnaire can be found in appendix C, and all the answers to the questions requiring a ranking were on a 5-level Likert scale.

Discussion on similarity and contrast The first activity was intended to introduce the participants to the subject of the session – similarity and contrast – and was designed as an open-ended interview. This was done in order to allow participants to explore their own understanding of similarity and contrast, and, with the help of the tutor, to establish a set of criteria that could guide participants through the rest of the session.

The tutor initially asked all the participants to explain their definitions of similarity and contrast in the most general terms that they could think of. It was made clear to them that they could refer to any field that they preferred, and produce any example that came to mind. It was also explained to them that discussing similarity and contrast in melody could be difficult for someone with little musical experience, so discussing these concepts in broad, general terms could provide focus on aspects that could be later related to melody, and some form of guidance through the session.

The discussion was directed by the tutor toward talking about criteria for judging similarity and contrast between concrete and abstract objects. A few props – such as chairs, balls of different materials and sizes, and other objects available in the room – were used if and when necessary, and according to the interests of the participants. When the participant and the tutor thought that nothing more could be added, the discussion was directed toward music. This involved discussing the notions of similarity and contrast in melody, and the idea that they could be used to create structure and narrative.

Listening and classification exercise This first exercise performed using the DTMI was designed as a transition between discussing similarity and contrast in general terms, and discussing them in the context of melody. This was done in order to make participants aware of how they interpreted melodies to be similar



(a) (b)

Figure 5.1. Examples of answers to the "listening and classification" exercise.

or contrasting. Therefore, they were encouraged to keep the previous discussion in mind, and see if they could relate it to their choices in this exercise.

The application shown in figure 5.2 was used for this exercise. The purpose of the exercise was that the participant would listen to the three short melodies presented by the application, and classify them in terms of similarity to, and contrast between, each other. All the melodies used in this exercise were composed beforehand by the researcher. A set of parameters were considered – i.e., contour, dynamics, mode, rhythm – and each group of three melodies comprised a base melody and two variations according to one, or more, of those parameters.

Participants were instructed to keep the two melodies that they considered similar inside the circle, and to drag the contrasting one outside. They were also given the option to clarify their choices by using the distances between the icons on screen to show to what degree they thought that the melodies were similar or contrasting. For example, in figure 5.1a, the two melodies inside the circle are at an average distance between each other, and the melody that was regarded as contrasting is placed quite far away from the other two. This was considered an indication that the two melodies inside were reasonably similar, and the one outside was contrasting with both the ones inside. By contrast, in figure 5.1b, the three melodies are placed in close proximity across the circumference, with the two similar inside the circle, and the contrasting one outside. This was taken as an indication that the three melodies were quite similar to each other. After each set of three melodies, the tutor asked the participants to explain their choices. Using distance in this way was optional, and in fact very few participants took advantage of it.

The twelve groups of three melodies were composed beforehand by the tutor, and they were presented in the same order to all participants. A set of parameters were considered – i.e., contour, dynamics, mode, rhythm – and each group of three melodies comprised a base melody and two variations according to one, or more, of those parameters. For example, a group could comprise a melody in a major scale, a variation in a minor scale on the same tonic (e.g. from C major to C minor), and a variation of the first melody with the contour turned upside-down. This was done so that the participants would be exposed to several different types of similarities and contrasts. All the melodies were recorded using a MIDI sequencer, and played using the timbre of a piano.

Challenge-response exercises The second exercise, and the first that used the previously developed DTMI, was intended to take the notions that participants acquired thus far and put them to use by composing responses to given short melodies according to instructions. This exercise comprised seven presentations in each of which two identical blocks were presented to the participants: one containing a pre-composed melody (the challenge), and one empty so that they could compose the response. The blocks used as stimuli are available in appendix C. The purpose of the exercise was two-fold: for the participants to become familiar (i) with the DTMI, and (ii) with how the criteria that they had just discussed could be applied to music making. In order to stimulate the participants to think about strategies for melodic similarity and contrast, increasingly strict constraints on the range of pitches were implemented. The first three presentations used a pentatonic scale; the following two used a *ditonic* scale (using only two pitches), which limited the pitch and encouraged the participants to consider rhythm more than they might have done in the first three presentations; the last two used a *monotonic* scale (using only one pitch) that forced participants to work exclusively on rhythm. On each presentation, the tutor instructed the participant to compose either a similar or a contrasting melody, and asked them to explain their reasoning afterward. These explanations were recorded in a notebook. The presentations were proposed to the participants in the following order: 1. similarity 2. contrast 3. participant's choice 4. similarity 5. contrast 6. similarity 7. contrast, thus the analysis refers to this numbering scheme. The "participant's choice" presentation was introduced to give the participants a feeling of control on how the session was carried out.

Fill-the-gap exercises The purpose of the third exercise, as explained to participants, was to develop a sense of how similarity and contrast could be used to suggest a narrative with melody. Participants were presented with a series of short melodies, composed of three to four blocks, and connected in order to form a single sequence. Some of the blocks were pre-composed, while some of the blocks were empty: typically, when three blocks were presented, the first and last were pre-configured, and the middle one was left for the participant; when four blocks were presented, either the first and last, or the first and third blocks were pre-configured, while the others were left for the participant. The sequences used as stimuli are available in appendix C. The task was for participants to complete the empty blocks as they saw fit according to the purpose of the exercise. After each presentation, the tutor asked the participants to explain the reasoning behind their response, and whether they could imagine a narrative based on the melody that they had just composed. These explanations were recorded in a notebook.

Storytelling exercise In the last exercise, participants were asked to compose a melody that, in their opinion, could express a story. Participants were told that they could create an original story, or refer to an existing one. It was also explained to them that the story would be analysed in conjunction with the melody that they were going to compose, in order to understand how they used similarity and contrast in telling a story with music. At the end of the exercise, participants were asked to tell the story in words, and explain how, in their opinion, the melody expressed the story. The purpose of the exercise was to see how the notions of similarity and contrast could be used to compose a melody that suggested a narrative. The length of the melody was only limited by how many blocks could fit in the screen. In practice, up to 24 tightly packed blocks could be created, although with some overlap that would possibly make some controls difficult to operate. The blocks that participants were given to work with were configured with a C major scale extending between MIDI C_3 and C_4.

Debriefing and post-session questionnaire A short debriefing was offered to the participants, following up on their work on the last exercise. This was to allow them to discuss their work with the researcher, and to reflect on the choices that they made, and on the criteria they used to establish structure and narrative in the melody. Lastly, participants were handed a feedback questionnaire, that was identical to the one used in Study 1, in order to assess their experience. All the answers were collected on a 5-level Likert scale to allow comparison with the pre-session questionnaire.

5.3.2. Configuration of the DTMI

For the composition exercises, the music composition application used in the previous study was adapted to present a series of exercises, as described in section 5.3.1. All these exercises used the modular configuration of the prototype (see section 4.3.1), in which multiple blocks representing very short melodies could be combined in different orders to create longer melodies. The configuration parameters can be found in appendix C. The listening and classification exercise used the application described in section 5.4.

5.3.3. Handling of participants

Participation in this study was voluntary, anonymous, and involved one participant per session. Participants were persons with any level of musical experience who were willing to improve their music appreciation skills. The background skills of the participants were assessed individually through a self-evaluation questionnaire in order to have some context when analysing their sessions.

Despite the fact that participants with no musical experience would have been preferable – as this would have made it easier to evaluate the DTMI's viability as an educational tool – obtaining a reasonable sample size was prioritised at the expense of obtaining uniformly inexperienced participants. It was therefore decided to consider as a "beginner" anyone who had never received music education, or that had for up to two years. This circumstance was consistently confirmed by the participants to coincide with compulsory music classes in school, typically attended several years in the past, as discussed in section 4.3.2.

5.4. Methodology

The methodology used in this study was largely based on the general one described in chapter 3. This section explains how that methodology was implemented for this study, and how each technique was used to provide the evidence listed in the previous section.

5.4.1. Listening and classification exercise

For the listening and classification exercise described in section 5.3.1, a new application was developed (figure 5.2). This application presented a series of groups of three related melodies, represented by three square icons. The groups comprised a base melody, and two variations produced taking the base melody and varying one or more parameters, such as contour, rhythm, mode, and so on. Participants had to listen to the melodies in each group, one group at a time, and to classify them by similarity and contrast. Playing a melody was achieved by touching its icon, which in turn changed its appearance to indicate the elapsed timed through a left-to-right progress bar. The answers recorded by the application provided a record of the participants' criteria for melodic similarity and contrast (SQ 2.1).

The groups of melodies were purposely composed to make the decisions easy at the beginning – by making the variations of the parameters evident

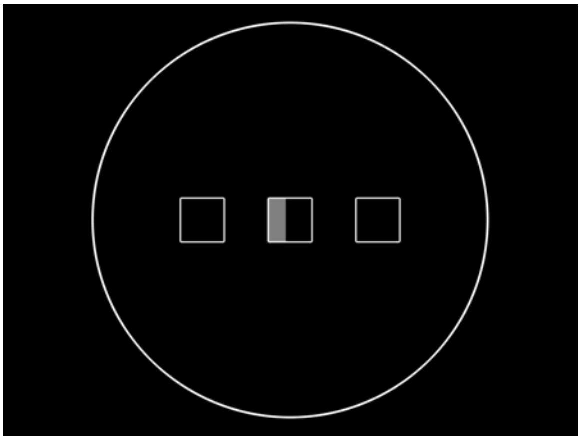


Figure 5.2. A screenshot of the application developed for the "listening and classification" exercise.

or by working on just one parameter per group – and increasingly difficult toward the final groups – by varying the parameters more subtly, or by varying multiple parameters within a group. Because of this, one might expect either that participants would take increasingly longer in making their decisions, or that they would take about the same time for all groups, possibly suggesting increasingly random decisions after failing to make a rational one in a certain amount of time. To weigh the participants' answers, the times that they took in answering each presentation were measured. This was done using the timestamps that the application logged along with the answers, from the moment when the application was started, to the moment when the participants gave their answer to the twelfth presentation.

5.4.2. Video recordings

Since the researcher was actively involved in the entire session, acting as a tutor, it was decided that video recordings were not necessary in this study. Instead, annotations were made in a notebook, including comments, non-verbal communication, and so on. Nevertheless, this provided data that was both rich and succinct, as shown in section 5.5, and provided part of the evidence used in answering all the sub-questions. However, it is important to remark that this choice was made due to the nature of these sessions, and would probably be unsuitable for studies in which the researchers are not directly involved in the activities.

5.4.3. Feedback questionnaire

Comparing items Q3.1 and Q7 presents an issue, since the statements are formulated differently. Q3.1 – "*How confident are you in your ability to compose original music?*" – asked to express the answer with a number between 1 and 5. Q7 – "*I am confident in my ability to compose original music*" – asked to check one in five possible boxes from 1 to 5. Because of this difference, comparing the answers may be problematic. It was, however, decided that, since the values were expressed in integers in both cases – i.e., all the participants answered using integers in Q3.1 – a comparison could still be reasonably made. Furthermore, since the two questionnaires were printed on the two sides of the same sheet, many participants actually looked back at their previous answer. For this reason, it was assumed that a variation in their answers reflected an actual variation in their confidence.

5.4.4. Thematic analysis for the use of the DTMI as discussion mediator and exploration support tool

The comments and the melodies produced during the sessions were analysed for understanding how the DTMI could support the discussion of musical concepts between its users and a tutor (SQ 2.3). In doing so, only two of the themes proposed by Hornecker et al. (2006) were used.

Tangible Manipulation (TM), to see how they physically interacted with the DTMI, and to see whether the DTMI afforded participants easy access to the representation of music, and allowed them to experiment with music in small steps. In particular, the following behaviours were observed.

Gestures: editing notes, starting and stopping playback, creating new blocks, dragging blocks, connecting multiple blocks.

Configurations: forming sequences of blocks.

Expressive Representation (ER), to see whether the DTMI, through the visual representation of melody, afforded participants a way of discussing aspects of similarity and contrast in melody. In particular, the following aspects were observed:

Visual representation: use of contour shapes, use of visual comparisons between blocks, use of the criteria for similarity and contrast discussed during the session.

Aural representation: use of contour descriptions, use of the criteria for similarity and contrast discussed during the session.

The theme **Embodied Facilitation (EF)** was used in the analysis of Study 1, and provided insight into the usability of the music composition application. However, since this theme was thoroughly used in the usability analysis performed in Study 1, it was considered that it would provide no additional insight in this study. Therefore, it was decided to ignore most of it – specifically, the parts concerned with physical constraints that affect the users' ability to collaborate. Instead, ER was modified to investigate elements of *tailored representations* – building on the users' experience and skills – which is part of theme Embodied Facilitation. The theme **Spatial Interaction (SI)** was ignored for the reasons stated in section 3.2.2 – i.e., the system under consideration is a horizontal touch-screen that users interact with by standing close to it.

5.4.5. Thematic analysis for the use of similarity and contrast in describing and suggesting narrative in melody

Two additional themes were used to analyse the contents of the discussions, as well as the melodies that were produced. These themes were used to organise the data in relation to the evidence needed, as explained in section 5.2.1. The following are the themes and sub-themes that emerged from the dataset.

Development of criteria for similarity and contrast, to see how participants developed ways of thinking about melody in terms of similarity and contrast. In particular, two sub-themes emerged from the transcripts: the idea that

similarity is not identity, but a property that can be nuanced depending on a variety of aspects; and the necessity for **comparability and relatedness** in order to produce meaningful comparisons, and particularly to determine contrast.

Use of criteria for similarity and contrast in suggesting narrative, to see whether and how participants used the criteria that they had developed in working with melody that express narrative. In particular, the data shows that participants used four criteria in identifying, and composing for, similarity and contrast. These were: the use of **mood**, particularly to identify contrasting moments; the use of different **themes** to signal different situations or characters in the narrative; the **visual** representation of music, in working with both similarity and contrast; and the use of **variations** of a theme, to suggest an evolution in one particular situation, or of a character, in the narrative.

5.4.6. Storytelling melodies

The analysis of the melodies composed during the storytelling exercise was mainly based on the explanations that the participants gave regarding how they thought that the story mapped onto the melody. This analysis was done with the intent of understanding what strategies participants used in performing the exercise, and whether and how they used similarity and contrast, particularly in the ways which they discussed during the session.

5.5. Findings

Twenty-four participants volunteered for the study, coming from staff available on the Open University campus. Excluding the initial discussion and the final debriefing, the sessions lasted approximately between 50 and 128 minutes (mean = 81’ 33”, sd = 21’ 14”).

years	participants
≤ 2	15
$3 \div 10$	9

(a) Duration of music studies (including none).

	participants
beginners	15
non-beginners	9
total	24

(b) Breakdown of the participants.

Table 5.1.

5.5.1. Demographics

The demographic data collected with the pre-session questionnaire are summarised in table 5.2. Fifteen participants had studied music for two or fewer years (Q1.1, mean = 0.73 years, sd = 0.96 years) and therefore were considered beginners according to the criteria explained above. The remaining nine participants had studied music for 3 to 10 years (mean = 6.33 years, sd = 2.92 years), therefore were not considered beginners (table 5.1a). Twelve participants said that they played at least one musical instrument (Q2), although some specified that that was "*years ago*". The most frequently reported instrument skill was 2 out of 5 (Q2.1).

Twenty participants said that they had never tried to compose original music before (Q3), and thirteen of these twenty were beginners. Beginners felt slightly more confident in their ability compose music (Q3.1, mode = 2) compared to non-beginners (Q3.1, mode = 1). Regardless of their expertise, 21 participants reported a confidence level of either 1 or 2, while the remaining 3 participants reported a confidence level of 3. Therefore, self-confidence in composition ability was considered low for most participants in this study.

5.5.2. Feedback questionnaires (SQ 2.4)

Table 5.3 summarises the participants' self-assessment of their experience in the study. This section reports on findings from the questionnaires that were used to inform the subsequent analysis of the sessions. The feedback questionnaire

	no	informally	formally
beginners	**9**	5	1
non-beginners	0	1	**8**
total	**9**	6	**9**

(a) Q1: Have you studied music?

no	one	more
10	2	3
2	3	**4**
12	5	7

(b) Q2: Do you play a musical instrument?

never	occasionally	often
13	1	1
7	2	0
20	3	1

(c) Q3: Have you ever composed original music?

	1	2	3	4	5
beginners	0	**4**	1	0	0
non-beginners	1	**3**	2	1	0
total	1	**7**	3	1	0

(d) Q2.1: How would you rate your skills on your best instrument?

1	2	3	4	5
6	**6**	3	0	0
5	4	0	0	0
11	10	3	0	0

(e) Q3.1: How confident are you in your ability to compose original music?

Table 5.2. Summary of the answers to the demographics questionnaires

comprised the following items, rated on a scale between 1 (strongly disagree) and 5 (strongly agree).

Q4. I felt that accomplishing the task was difficult
Q5. I enjoyed making music
Q6. I concentrated intensely on the task
Q7. I am confident in my ability to make original music
Q8. I think that I will make original music in the future

Stress and enjoyment

Participants found the tasks averagely difficult to perform (Q4). It is worthwhile noting at this point that participants were asked to consider all the tabletop activities together as "tasks", in rating item Q4. Observations made by the researcher during the sessions suggest that not all these activities were correctly understood. In particular, in the challenge-response and fill-the-gaps exercises, participants often hesitated before composing their answers, and explained them afterwards with vague expressions such as "*it's my gut feeling*", or "*I really don't know why I did this*". However, when encouraged to elaborate, participants usually produced more coherent explanations – e.g., "*characteristic jump up that I kept in reverse*", "*I wanted to take that syncopation out*", and so on, as discussed in section 5.5.4.

Despite the perceived difficulty, 19 participants said that they "*enjoyed composing a piece of music*" (Q5) while one answered 1 to this question; and 12 participants said that they "*concentrated intensely on the task*" that was proposed (Q6). This may sound counterintuitive at first, especially in comparison to the perceived difficulty of Study 1; however, during the debriefing, many commented that the tasks were "*challenging*", "*not always intuitive*", one even "*wished you told me what you wanted from me!*".

Self-confidence

Twenty-one participants, among which were twelve beginners, reported low confidence (< 3) in their ability to make original music before the session (Q3.1, mode = 1, across all the participants). Of these 21, 18 said that they were at least somewhat likely (> 1) to consider trying to make original music again after the session (Q8), and 12 of these 18 rated this between 3 and 5. Of the 4 participants who reported having made original music at least once in the past, none of them reported being less likely to try again in the future. Furthermore, of the 20 participants who reported having never made original music before, only 3 reported being unlikely to try again in the future; on the other hand, the remaining 17 – 12 of which were beginners – said that they were at least somewhat likely (> 1) to try again. This result is encouraging, and can be explained in light of the tension between the difficulty and the challenge that participants experienced in this study. This general increase in confidence, and the positive outlook on the possibility of trying to make original music in the future, suggest that combining a simplified, playful musical interface with appropriately designed exercises can provide a challenging and motivating experience that could encourage people in engaging further with music, and learning more about it.

5.5.3. Usability (SQ 2.3)

Study 1 provided a good usability assessment of the music composition DTMI. Therefore, this time the prototype was analysed only briefly in that respect, noting any additional insight. The application used in the listening and classification exercise was also assessed for usability. However, because of its minimal functionality, and because it was only used in a very specific capacity in this study, only a brief assessment was performed.

Listening and classification The interface presented the three melodies as icons arranged parallel to the long side of the tabletop, and in the centre of it. No participant had difficulties reaching the three icons with their hands, and dragging them anywhere on the interface, regardless of where they stood around the tabletop. In fact, two participants chose to sit in a chair along one of the long sides of the tabletop, and yet had no problems in performing the exercise. All the participants were given a detailed explanation of the task before they

	1	**2**	**3**	**4**	**5**
beginners	1	**7**	3	4	0
non-beginners	**3**	2	2	1	1
total	4	**9**	5	5	1

(a) Q4: I felt that accomplishing the task was difficult.

1	**2**	**3**	**4**	**5**
1	0	4	2	**8**
0	0	0	**6**	3
1	0	4	8	**11**

(b) Q5: I enjoyed making music.

	1	**2**	**3**	**4**	**5**
beginners	1	1	3	3	**7**
non-beginners	0	1	2	1	**5**
total	1	2	5	4	**12**

(c) Q6: I concentrated intensely on the task.

1	**2**	**3**	**4**	**5**
2	3	**7**	2	1
1	**4**	3	1	0
3	7	**10**	3	1

(d) Q7: I am confident in my ability to make original music.

	1	**2**	**3**	**4**	**5**
beginners	1	**6**	3	3	2
non-beginners	2	1	**3**	**3**	0
total	3	7	6	6	2

(e) Q8: I think that I will make original music in the future.

Table 5.3. Answers to the feedback questionnaires

started working on the exercise, and were also told how to use the interface to perform it. The explanation comprised only verbal instructions, encouraging the participants to perform the actions by themselves to become familiar with the system. All the participants showed that they understood how to use the interface after performing just a few actions – such as dragging the icons, and tapping on them to listen to the melodies. This is evidence that the interface used for this exercise provided *lightweight interaction* (TM), meaning that it could be learned through small, experimental steps, and that it gave immediate feedback – e.g., through the progress meter, to indicate what happened following users' actions.

Music composition Findings reported in section 4.2.1 were largely confirmed in this study. In particular, all the participants tried to interact with the music composition interface within seconds of seeing it ready to be used – e.g., by touching the blocks, trying to move them around, and so on. At that point, the tutor offered to explain how to use the DTMI, which only two participants refused – "*No, I want to figure this out on my own!*", "*Looks easy enough* [...] *but I guess you're not going anywhere, right?*". The explanation was offered so that the participants could focus entirely on the exercises, instead of on learning how to use the DTMI. The tutor explained how to use the interface mainly through verbal instructions, prompting participants to perform actions by themselves. Only occasionally, after repeated failed attempts of the participant, did the tutor intervene to demonstrate the correct way of performing the troublesome actions.

The action that participants struggled the most with was connecting blocks to form a sequence. This was something that emerged in Study 1 as well, and the connection handles were made approximately 25% larger in this study in the hope of making this easier (see figure 5.3). However, it became clear that the participants often performed this gesture with a quick, imprecise stroke that often missed either the source or the destination outlet, and sometimes both. After the first two sessions, the prototype was modified to redress this issue: the active, invisible area was made approximately 25% larger than the

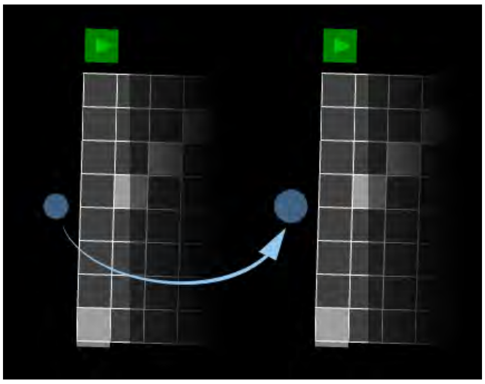


Figure 5.3. Connection outlets enlarged by 25%.

circles representing the outlets. This resulted in a much lower failure rate in performing this action. It is worthwhile noting that the blocks were presented already connected, but some participants preferred to disconnect them and work on individual blocks, rather than on the entire sequence at once, and then manually going back and forth between blocks to check their work.

In summary, both applications presented very few usability challenges, which were addressed promptly to improve the experience. Participants made close to no negative comments on the interface, except for those who expected polyphony within blocks. However, when the rationale for monophony was explained to them, they understood and agreed that it was the right choice.

5.5.4. Thematic analysis (SQs 2.1, 2.2, and 2.3)

In this section, the sessions will be analysed using the themes previously identified in order to gather evidence to answer the research questions.

Developing criteria for similarity and contrast

There was an initial discussion between the participant and the tutor. The tutor explained the participant that this was a way of getting them to talk about their definitions and criteria for similarity and contrast, and therefore a way for them to discuss and reflect on these explicitly. Participants often expressed concerns that they did not know enough about music to talk about similarity and contrast in that context – often, they mentioned lacking "*the vocabulary*", not being "*a musician*", and one thought he was "*probably not creative enough, but I'll play along*"; therefore, it was explained to them that they could discuss any other context that they preferred – for example the field that they worked in, their interests, their daily activities and experiences, and so on – and then keep this discussion in mind as a guide through the rest of the session. In particular, the importance of the initial discussion was stressed by the tutor when presenting the listening and classification exercise: this exercise was explained to participants as a way to carry on the discussion of similarity and contrast in the context of melody. At that point, many of the participants were still unsure about their ability to discuss music – e.g., "*I still know nothing about music*", "*I have clearer ideas on similarity and contrast, but I still don't know how to turn them into music*" – but were also pleased with how the discussion went – e.g., "*I'm starting to see how we can discuss music this way*", "*I thought it was going to be like an oral test, in school, but you were no wicked teacher*", "*well, that wasn't hard, was it?*".

Four participants explicitly discussed musical aspects, among others, during the initial discussion. For the purposes of the following analysis, their comments were categorised in the same abstract way as the other participants'.

Similarity is not identity When asked to define similarity in their own words, participants often started by thinking about identity, and the idea of sameness – e.g., "*it's 100% identical, it's the same*", "*similarity is when two things look identical… or similar*", "*same mood, same tone, same intensity*", "*it means having common grounds, the same language, ideas, perception, similar direction, perspective, overlap*". However, all the participants soon recognised that that was not a sufficient definition. The nature of the records of the discussions make this difficult to show, but in reality the tutor, when faced with considerations about identity, especially at the very beginning of the discussion, always prompted the participants to think again, and see if this was the only way in which they could think about similarity. One could speculate that, in this way, the tutor steered the discussion, but in reality no participant expressed – verbally or not – feeling forced or compelled to discuss options that they considered unreasonable.

Comparability and relatedness The observation that "similarity does not mean identity" resulted in a discussion on how objects can be similar, or contrasting, and on what these two terms really meant to the participants. At that point, the discussion started involving concrete examples, some of which were brought up by the participants – examples varied widely, covering buildings, hot beverages, cars, animals, philosophy, and so on – and some of which were brought up by the tutor to make it easier to compare the discussions – for example, objects that were present in the room were discussed, such as chairs – chairs of different builds, stools, and thrones – but also examples that emerged during the first few sessions were considered, such as tea and coffee, different types of chairs, elephants, balls, and vehicles, and so on.

Notably, two types of dimensions – in the sense that was discussed at the beginning of this chapter – frequently emerged: functional qualities – i.e., qualities that relate to the function, purpose, and functionality of objects – and perceptual qualities – i.e., qualities that can be perceived through our senses. Functional qualities were discussed by all participants, with 18 of them mentioning function and purpose spontaneously, and the other 6 discussing these upon suggestion of the tutor. Different participants often repeated the same observations: concrete examples were often used, and suggested by the tutor, so some repetition was to be expected. For this reason, not all the observations were recorded in full. The following are some examples of such observations made by multiple participants.

- *You sit on all* [the] *three* [chairs], *but for different reasons.*
- *an office chair is more comfortable than both a throne and a stool: on a throne you are a ruler, you have responsibilities; on a stool you sit on a hard, flat slab, probably milking cows?*
- *Take bottle openers: you get the same result, for different drinks, but with different mechanics.*
- *Laptops and desktops, they are different, both have the same function, they are similar in that.*
- *If you can use* [two objects] *for the same thing, they are similar.*

- *Function counts, that's important, then how you experience things, and tiny details.*

On the other hand, perceivable qualities – such as shape, materials, textures, and so on – were spontaneously discussed by 15 participants, and were subject of discussion for the remaining nine – often because the tutor asked them to discuss these features. The following are some examples of the ways in which perceivable qualities were discussed by participants.

- *Those have four legs, that one has a base, and it rotates, and the textures and materials are all different, but they're all chairs.*
- *They all look like chairs, but the materials and shapes are different, and also the level of comfort.*
- *I wouldn't sit on that* [metal chair] *for my daily work.*
- *That* [padded] *chair looks more comfortable than this.*
- *That* [frame] *is made of metal, this is made of wood, it's more classic, warmer.*

Discussing perceivable features brought 17 participants to consider the issue of comparability, that is the possibility of comparing objects. These participants discussed, in different ways, the existence of a threshold in the number of dimensions, and in the similarity or contrast along these dimensions, past which they would not be able to compare two objects in order to decide whether they are similar or contrasting. Particularly referring to contrast, 15 of these participants mentioned the need for relatedness: that is the need to be able to find a way – one, or more, dimensions – to put objects in relation before being able to compare them for contrast – in other words, finding a common set of dimensions. If this is not possible, then it is not possible to talk about contrast, but rather about difference. The following are examples of the ways in which participants discussed this idea.

- *Black and white, it's clashing, but they're still colours* [...] *a throne is so extremely different from a stool, I'd say they contrast. They're still chairs, though.*
- *Not totally different, there has to be a connection.*

- *Striking difference, like opposites, but also two things have to be comparable in some ways.*
- *I can agree on that respect* [carrying people]*, but no, a van is a car, an elephant is an animal.*
- *Opposites, in meaning, which means they have a relationship.*
- [Contrast is] *a comparable difference.*
- [Elephants and cars] *"there's contrast in their… fleshiness, but similarity in their function".*
- *Different levels of detail give different types of similarity.*
- *So different, with some similar bits, otherwise they are just different.*
- [Carrying people] *in the context of transportation… but in the context of zoology, cars don't even exist.*
- *It comes from comparisons, if you can't make a comparison, you can't say there's contrast.*
- *There may be similar aspects, but striking difference in certain aspects.*

From these considerations, four participants discussed the notion that one can compare the same objects under different aspects. While this is true, these participants discussed the fact that, for the comparison to be meaningful, the context in which it happens has to make sense. This means that there is no point in comparing sizes if the objects of comparison are of drastically different nature – for example, an elephant and a tennis balls – but it makes sense if the context makes sense – for example, comparing an elephant, a car, and a van, in the context of transportation. The following are some of the ways in which participants expressed this idea.

- *If you think like that* [comparing individual dimensions] *then you can compare everything on one particular aspect. It's like comparing elephants and tennis balls, it makes no sense.*
- *Elephants have been used as transport for centuries, haven't they? They are similar, just in their historical context.*
- *I can agree on that respect* [carrying people]*, but no, a van is a car, an elephant is an animal*

- *They* [elephants and cars] *have more that can be compared than just a tennis ball. In that sense, they are more similar than contrasting.*
- *I think you can compare* [elephants and cars], *it depends on what: people carried? Free will? The outcome is different.*

In summary, the discussions did not bring up particularly surprising points, with respect to the literature discussed at the beginning of this chapter. However, this initial discussion was mainly meant to allow participants to reflect on how similarity and contrast are commonly understood and used, and to make them come up with criteria that they could use to judge similarity and contrast in melody.

Discussion of similarity and contrast in melody

As the discussion started moving towards melody, many participants looked more confident than before in their ability to carry on the discussion. In particular, they started coming up with more examples without being prompted by the tutor, and suggesting new aspects to discuss. However, the notion that comparisons could be performed along a wide variety of dimensions was still of concern for almost all them. This was discuss dDuring the transition between the two partsgeneral discussion, and the discussion on melodic similarity and contrast, this was briefly discussed, and the tutor encouraged all the participants to list all the dimensions that they could think of for comparing melodies. Participants mentioned many different dimensions, often complementing their words with gestures and examples when describing aspects for which they were not sure what words to use – e.g., frequently, the word *melody* was used, but complemented with hand-waving gestures, to signify contour; terms such as *speed* and *rhythm* were used to indicate tempo; *sound*, *colour*, and *type of instrument* were often used to mean timbre; and so on. Despite the initial concern expressed by many participants, discussing aspects and examples with the tutor resulted in all participants being able to produce at least two or three criteria each.

The following is the analysis of the answers to the listening and classification exercise, organised by groups of melodies in the order in which they were

group	parameters
1	**contour** (intervals)
2	**mode, contour**
3	**rhythm** (son clave, rumba clave), **expressivity** (legato, staccato)
4	**contour, expressivity** (legato, staccato)
5	**mode, contour**
6	**mode, rhythm** (syncopated)
7	**contour, rhythm** (straight vs. shuffle)
8	**contour, expressivity** (dynamics)
9	**mode, contour**
10	**mode, expressivity**
11	**mode, rhythm** (syncopated)
12	**contour**

Table 5.4. List of the parameters that were manipulated to compose the melodies in the "listening and classification" exercise.

presented to the participants. Table 5.4 shows the list of parameters that were manipulated to compose the variations in each group, and table 5.5 shows the list of the criteria for similarity and contrast that emerged as relevant from the analysis. It is worthwhile noting that, although the task was to classify the melodies by similarity and contrast, contrast was never brought up by any participant. Instead, they all preferred to describe the melody that they were excluding as "*different*", and one participant named the exercise "*spot the odd one out*". The analysis takes this into consideration, thus the lists of criteria that follow each analyses is to be considered a list of criteria for similarity and difference. However, when discussing this with the participants at the end of the exercise, they all agreed that, in light of the previous discussion regarding dimensionality, and the need for relatedness to determine contrast, the same criteria that they identified in the exercise could be used to determine contrast in melody as well as similarity.

	criteria for	
group	**similarity**	**difference**
1	contour	contour
2	contour	contour
3	expressivity	expressivity, rhythm
4	contour	expressivity
5	contour	contour, mode
6	mode (over rhythm)	mode, rhythm
7	contour, recognisability	recognisability
8	contour	expressivity
9	recognisability	recognisability
10	mode	expressivity, mode
11	mode, rhythm	mode, rhythm
12	recognisability	rhythm

Table 5.5. List of the criteria for similarity and difference identified by the participants in the "listening and classification" exercise.

Results of the listening and classification exercise

Group 1 This group comprised three melodies of five notes each, three ascending and two descending, with one of the three melodies moving in steps, and the other two moving in skips of different sizes. Fourteen participants considered the two melodies moving in skips to be similar, and the one moving in steps to be different – some commented that the melody moving in steps was "*more linear,* [with] *smaller intervals*", and "*more harmonic, falling in the right place*". The ten remaining participants chose to mark as different the melody moving in skips which had one "*odd note*". The participants justified their choice with "*instinct*" and with the presence of the odd note.

Group 2 This group comprised one melody in a minor key, one melody with the same contour in a major key, and a version of the major one with every note in an even position being a repetition of the previous note. All the three melodies started on the same note. Twenty-three participants chose the first two melodies as the similar ones, often justifying their choice with the presence of the "*repeated/doubled*" notes in the one they deemed different, with one noting that it had "*not the same ups and downs*". Other participants mentioned that the different melody was "*feeling slightly/totally different*" to them, without being able to elaborate further.

Group 3 This group comprised three melodies of two identically alternating notes in the rhythms of son clave and rumba clave played staccato, and rumba clave played legato. Two participants chose the son clave melody as the different of the three, both justifying their choice with rhythm. On the other hand, 22 participants chose the rumba clave legato as the different melody, considering instead the two staccato melodies similar – one "*picked this* [legato] *because it didn't feel right*", three considered the legato "*slower*", and the rest explicitly used the terms "legato" and "staccato", or they talked about the duration of the notes.

Group 4 This group comprised one melody played legato, the same melody played staccato, and a version of the first melody played legato and with a somewhat upside-down contour. Six participants picked the staccato version as their "different" choice – "*jerky staccato*", "*not harmonious, I didn't like it*", "[the two played legato] *fit better together than with the odd one*". The remaining 18 participants instead chose to consider the first two ones similar, with 11 of them suggesting that contour was the determinant factor, and the remaining 7 offering no explanation.

Group 5 This group comprised one melody in a major key, a version of the first in a minor key, and a version of the second with reversed contour. Eleven participants picked the first melody as the different one – justifying their choice with "*feeling*" and "*mood*" – and ten participants picked the third melody – justifying their choice with the different contour. Of the three that considered the second melody to be different, one participant said that "*these two* [similar] *seem more in harmony, this one has an odd note that doesn't seem to be there in the* *other two*".

Group 6 This group comprised a base arpeggio in a minor key, a version of the same in a major key, and a version of the first arpeggio played using a shuffle rhythm. The two major and minor arpeggios were deemed similar by 19 participants, 18 of which cited rhythm as the reason for considering the third one different. On the other hand, five participants deemed the arpeggio in a major key as the different one, although only one of them mentioned that the first and third melodies had the exact same notes, but a different rhythm.

Group 7 This group comprised a short blues phrase, a version of the same played in straight eighths, and a version of the first with a somewhat upside-down contour. Fifteen participants considered the latter to be the different one, mostly suggesting that contour played a role, although some could not "*recognise that*", finding it a "*different tune*", "*completely different*". Five participants picked the straight eighths version as the different one, justifying their choice with the different rhythm. The remaining four chose the original phrase as the different one, but offered no coherent explanations.

Group 8 This group comprised the first eight bars of Danilo in "Lippen Schweigen", from the Merry Widow, first played without dynamics, then played with dynamics, and lastly, a version of the second with a different contour, composed in a way that it could follow the original eight bars, but purposely not the phrase that actually follows in the original piece. Eighteen participants determined that the first two were the most similar – citing contour as the primary source of similarity – although one commented that the first two were the "*same melody, but the odd one could fit as well*". Four participants chose the first melody as the different one, citing the lack of dynamics as the differentiating factor. The remaining two participants thought that the second melody was different, although they gave no reason for this.

Group 9 This group comprised the first four bars of the folk song "Ah! vous dirai-je, maman" – which many native English speakers identified as "Baa, Baa, Black Sheep" instead – then a version of the same in a minor key, starting on a different note, and a version with a different melodic contour, but identical rhythm – one participant noted that "*it's all 'Baa, Baa, Black Sheep' played in different ways*". This observation is interesting because participants often provided familiarity, or recognisability, as their differentiating factor. In particular, the base and minor versions were similar for 12 participants because they could still recognise the melodic contour, whereas the minor version, and the one with the different contour were considered similar by the other twelve participants because they were both different from the one they recognised as the real, original version of the tune.

Group 10 This group comprised variations over the first few bars of the chorus of the popular song "Let it go" from Disney's animated feature Frozen. This was chosen because of its popularity at the time, and therefore provided another instance of recognisability, among other criteria. The first melody was the original version in a minor key, the second was a version of the first in a major key, and the third was a version of the first one played expressively as opposed to mechanically, like the first two. Half of the participants chose the third one as the different melody, explaining that they did so because of the less mechanical feeling – "*this has been played by someone*" – and instead considered the other two instead to be less dissimilar, and even "*the same tune*". The other half of the participants considered the major version to be the dissimilar one – "*not the same score*", "*there's a clear difference*", often adding that the mood in the major one was different. One participant was however quite confused, and said that all three were "*equally different*".

Group 11 This group comprised a melody in a major scale, a version of the same in a blues scale, and a version of the first melody played syncopated. Twelve participants indicated the blues melody as the different version, because it "*sounded off*", "*very minorish*", like a "*melody of the East, like Turkish*". In fact, seven of these explicitly mentioned the fact that the blues melody had different notes than the other two, that instead used the same pitches. The other twelve participants indicated the syncopated melody as the different version, making the major and the blues ones similar. In six cases, "*rhythm*" was used to explain the choice.

Group 12 This last group comprised a melody with a jazz feeling, a version of it transposed upward by a fifth, and a simplified version in which the dynamics were removed and only the notes falling on the beats were kept, and turned into crotchets. One participant indicated the first melody as the different one, but gave no explanation. The other twenty-three indicated the third, simplified version as the different one. Six of these explained their choice due to the different rhythm – one mentioned the durations of the notes, another the "*style*" without further qualification. Only two of twenty-three participants explicitly said that the first two variants were transpositions of each other.

Discussion of the results of the listening and classification exercise The explanations that the participants provided used a rather diverse vocabulary, therefore they were classified into five categories: contour, expressivity, recognisability, rhythm, and mode. These criteria were used by participants for determining both similarity and dissimilarity. The count of the criteria so categorised is shown in table 5.6. While some criteria were unique to the ways in which particular groups of melodies were composed (i.e., expressivity and recognisability), the others were used in one way or another in all the groups, therefore the counts reflect this – e.g., expressivity and recognisability are far less present than contour, because they were used in fewer groups of melodies.

Two strategies for classifying melodies were observed during the exercise. In one, participants chose started with identifying the two melodies that sounded more similar to each other, and concluded that the third was "the odd one out". In the other, they first identified the least similar melody of the three, and concluded that the other two were similar to each other instead. No participant used just one of these of for all the groups of three melodies, but proceeded

Criteria	Similarity	Difference	Total
Contour	**6**	3	9
Mode	3	**4**	7
Expressivity	1	**4**	5
Rhythm	1	**4**	5
Recognisability	3	2	5

Table 5.6. Count of the criteria identified by the participants in the listening and classification exercise.

in one way or the other, as they preferred. In the end, no strategy was used prominently in either of the twelve groups.

It was not very surprising to find that contour was the most frequently used aspect to judge similarity, since this is what is often found in the literature on melodic similarity, as discussed by Eerola et al. (2001) and Urbano et al. (2011). As in the initial discussion, where a single concept was described using widely different expressions, contour was often identified in different ways – such as "*pattern of notes*", "*intervals*", and "*scale*" – although some participants were more precise than others, using expressions such as "*ups and downs*", or mentioning that the melody "*goes down at the start*". On the other hand, when explaining the reasons for considering one melody different than the other, participants often identified several factors, for example *mode* – although very few participants explicitly talked about "*mode*", or the melody being "*major/minor*", preferring expressions such as "*weird/wrong note*", or expressions of mood such as "*happiness*", "*creepy*", "*odd*", and so on. In addition to mode, expressivity – meaning the style of playing, the difference in playing staccato or legato, and the use of dynamics – as well as rhythm were factored into the decision.

The different criteria that were primarily used in determining similarity and difference would seem to suggest that similarity in music can be determined in some objective way – contour, for example, can be described in analytical ways, and can be measured and compared objectively. Conversely, determining difference was approached in a more subjective way. It is true that rhythm can be described and measured objectively, and that mode is a clearly defined property of Western tonal music. However, only occasionally the participants described them analytically, resorting more often to vague statements, sometimes using unrelated terms – e.g., "*rhythm*", "*minorish*", "*creepy*", "*odd*". On the other hand, expressivity is an inherently subjective criteria which depends on an individual's sensibility – for example, for one person the use of dynamics may be more important than the tempo variations during a performance, and vice versa.

We can further analyse this exercise by looking at how long participants spent in classifying each group. Taking the time from the application's start-up means that time spent on the first group of melodies is noticeably higher than the others. The reason for this was that the application was started before the tutor began to explain the exercise to the participants. This created a bias of about 30-45 seconds for the completion times of the first presentation. Table 5.7 shows the average time, in seconds, spent by participants per group of melodies.

group	**mean** (s)	**sd** (s)
1	146.1	51.9
2	74	32
3	100.8	68.8
4	75.3	36.7
5	95.3	32.9
6	71.4	30.1
7	93.9	59.1
8	68.2	33.9
9	102.3	40.9
10	85.9	43
11	77.1	39.5
12	77.4	40.7

Table 5.7. Time spent by participants on classifying each group of three melodies.

Figure 5.4 shows two linear models fitted to the mean column when the time for group 1 is shortened by 30 seconds, bringing it to 116.1 s (in orange), and by 45 seconds, bringing it to 101.1 s (in blue). In both cases, although slowly, the average time decreases. This may suggest that the participants became

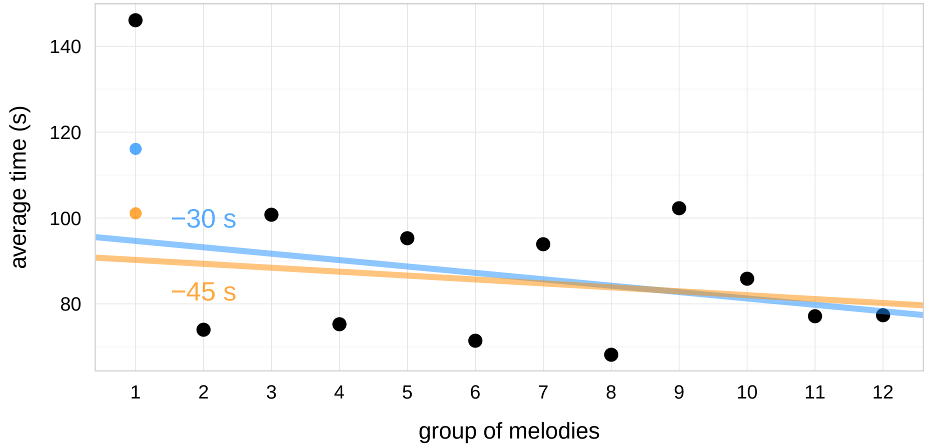


Figure 5.4. Average time spent by participants on classifying each group of three melodies (black dots), linear model with the first observation reduced by 30 seconds (blue), linear model with the first observation reduced by 45 seconds (orange).

increasingly confident in their ability to classify melodies, but it does not exclude that participants may have started making increasingly random decisions in increasing haste, perhaps due to increasing confusion and frustration.

Arriving at any of the conclusions suggested above was not in the scope of this study, and would probably require a larger sample, and a different experimental setup. Nevertheless, this exercise was successful in terms of allowing participants to become aware of the issues of melodic similarity, by explicitly reasoning about concrete examples. In fact, all the participants could classify melodies, and explain why their choices made sense to them, and therefore they were encouraged by the researcher to keep in mind the criteria that they had just established for themselves, and use them as a guide through the rest of the session.

Familiarising with criteria for similarity and contrast

After completing the listening exercise, participants were told that it was time for them to put what they had learned into practice, and to compose some music. Upon hearing this, many participants, and particularly those who were less musically experienced, expressed interest in the challenge, as well as concern regarding their actual ability to undertake it.

Challenge-response exercise

The most frequent strategy for responding to the challenges was to work on rhythm and contour – perhaps unsurprisingly, given that these two parameters were presented in an obvious way, and could be intuitively manipulated. Rhythm in particular was used through all seven turns, not just in those that forced participants to work with it. In the analysis that follows, the presentations of this exercise are grouped by the type of answer that they were requiring – similarity or contrast. The challenges of each presentation are available in appendix C.

Similarity challenges Presentation 1 was taken by many participants as a test-run, to understand how the application worked. Thirteen participants responded in an identical, or nearly identical way, often replicating the challenge and changing only one or two notes. In nineteen cases, participants maintained the same pattern of pauses, thus the rhythm, working instead with pitch. The groups of quotes presented in this section are some of the comments made by participants after responding to each challenge, explaining their choices.

- p. 16 – "*same pattern with slightly higher notes*"
- p. 17 – "*kind of transposed, but keeps the rhythm*"
- p. 19 – "*I didn't want to mess up the rhythm*"
- p. 20 – "*the blank spaces produce the same rhythm; they start the same way, end differently because otherwise it would not make sense*".

Five participants worked on both rhythm and pitch, producing results that they regarded as similar.

In presentation 4, participants were encouraged to think about rhythm, since they could only work with two pitches. Thirteen participants responded in identical, or nearly identical ways.

- p. 12 – "*same rhythm, keeps flow*"
- p. 17 – "*same rhythm, but different notes make it a bit different*"
- p. 19 – "*same rhythm, reversed notes*"
- p. 22 – "*I wanted to reverse that one*".
- p. 24 – "*identical patterns, shifted downs*"

However, this figure increases if we consider that some participants replicated the challenge shifting the starting beat, so that the two sounded identical if the starting beat was not known to the listener.

In presentation 6, thirteen participants replicated the challenge, either identically, or starting on a different beat. Nearly all participants were confused when faced with this challenge – i.e., the first that forced them to only use one note – and some doubted that they could do anything. In particular, some participants replicated the challenge starting on the first off-beat, acknowledging that it "*sounds the same*", having used the "*same pauses, same notes, just in different places* [following the same pattern]". In other cases, they did different things – "*same number of rests* [placed differently]" – sometimes ending with something that they did not expect – "*actually sounds more different than I wanted it to*".

Contrast challenges Presentation 2 was approached by participants in two main ways. In one case, they responded with something completely different and unrelated.

- p. 9 – "*random notes but avoiding to use the same as the given bar*"
- p. 12 – "[the response is] *very different,* [it] *stays up*"
- p. 16 – "*completely different pattern; repeated notes, no pauses*"
- p. 19 – "*different enough, faster, no gaps, overall higher notes*"
- p. 23 – "[the challenge] *starts low,* [the response is] *arrhythmical*"

In the other case, their responses included elements that, in their opinion, related the responses with the challenges.

- p. 2 – "[I] *reversed everything, increased speed*"
- p. 3 – "*high/low pitch, reverse pattern of pauses*"

- p. 13 – "*three notes, not just two, but these two are kind of the centre of mass; contrast should have some form of similarity*"
- p. 18 – same rhythm, reverse contour
- p. 21 – "*goes a bit down, with a similar rhythm*"
- p. 22 – "*there's a very characteristic jump that I kept in reverse, but also the rhythm*".

Presentation 5 was approached in various ways, yet in 20 cases participants could explain their intention, showing that they thought about what they wanted to do, and that they were able to do it. Like in presentation 2, many participants opted a response that was very different

- p. 4 – changed rhythm, speed
- p. 6 – "*first* [I made a] *reflexion but thought it was too similar; then all different*"
- p. 10 – "*totally different*"
- p. 11 – "*single note, legato vs. staccato*"
- p. 16 – "*all notes, no pauses*"
- p. 19 – "*more high notes, I inverted the proportions*"

or for one that kept a relation with the challenge – often using rhythm in this sense, but not necessarily by keeping it identical, rather by proposing variations of it

- p. 2 – "*reversed scale, squeezed timing*"
- p. 3 – reversed pitch, "*syncopated vs. straight*"
- p. 7 – "*quicker beat*", reversed contour
- p. 8, 14, 15 – reversed contour, same rhythm
- p. 13 – "*three notes, but with different rhythm*"
- p.18 – "*different spaces*"
- p. 20 – "*it's much busier, like something that falls into place*"
- p. 22 – "*I wanted to take that syncopation out; virtually the same notes*".

Presentation 7 was approached again in two ways. In one case, participants composed responses that contrasted the regularity of the challenge's rhythm with an irregular rhythm

- p. 2 – "*density*", regular/irregular rhythm
- p. 4 – "[this is] *monotonic,* [this is] *frantic*"
- p. 11, 20, 24 – "*regular vs. irregular*"
- p. 23 – "*this* [challenge] *had no urgency*".

In the other case, participants composed responses mostly based on the original rhythm, applying variations such as making it faster or slower, sometimes adding a few notes, and playing with pauses.

- p. 3 – "*inverted beat to carry on*"
- p. 6 – "*double speed, repeated pattern*"
- p. 12 – "*very different rhythm!*"
- p. 13 – "*three notes, but instead of 1-2-3 there's a 1-2-1-2*" [note: same as p. 12 starting on the first off-beat]
- p. 14 – "*faster rhythm*"
- p. 16 – "*different rhythm*" [note: same as p. 14 starting on the third off-beat].

In summary, the responses to the similarity challenges show that the participants often preferred to maintain the rhythm that was used in the challenge, and instead worked on melodic contour. On one hand, the literature on melodic similarity, reviewed at the beginning of this chapter, as well as the findings from the listening and classification exercise, indicate melodic contour as predominant over rhythm in determining similarity. Therefore, preferring rhythm to create similarity may seem contradictory. On the other hand, both the challenge and the response blocks that were presented to participants were equally short – equivalent to a single 4/4 bar – and played in a loop, like an *ostinato*, therefore a sense of rhythm could quickly emerge, possibly making it a more immediate and prominent parameter to suggest similarity between such short loops. However, this is not to say that melodic contour was never used in responding to the challenges; in fact, it was used in replicating small groups of notes – examples of this can be seen in the first challenge, for those participants who did not compose identical responses but still re-used the two- and three-notes figures moving upwards in steps, or in challenge 3, the participants who declared similarity often replicated the three-notes arch figure, either upward or downward.

On the other hand, the responses to the contrast challenges seem to show that participants worked coherently with the parameters that they had previously identified – rhythm in particular, since the application did not make it particularly easy to work with expressivity or mode. In the majority of the cases, participants were able to explain their reasoning, although some participant occasionally became confused and could not produce coherent explanations for their responses to certain challenges. This was, however, well within reasonable expectations, at this point in the session.

Fill-the-gaps exercise

The fill-the-gaps exercise was meant to let participants compose music in a more open-ended way: no additional instructions were provided to participants, save for the encouragement to think about whether the resulting melody could suggest some form of narrative. Although three participants identified close to no stories at all, nineteen participants produced at least an explanation of their reasoning, if not a suggestion of narrative, for nearly all the melodies. The turns in this exercise were numbered sequentially following the challenge-response exercise, therefore from 8 to 16.

The explanations comprised not only practical choices that participants made, describing the melodies in terms of contour and rhythm, but also showed that participants thought about the melodies on a more global, structural level. The groups of quotes that are presented in this section are some of the comments made by participants after responding to each fill-the-gap turn, explaining their choices.

- e. 8, p. 8 – "*I made a visual connection with ups and downs*"
- e. 8, p. 10 – "*blocks 1 and 3 sounded similar, so I wanted something more exciting*"

- e. 9, p. 13 – "[repetition], *kind of like Philip Glass*"
- e. 9, p. 15 – "[keeps rhythmic similarity to] *preserve hop-hop*"
- e. 10, p. 10 – "*I wanted to preserve the up/down feeling*"
- e. 10, p. 12 – "*exciting middle! suspense!*"
- e. 11, p. 9 – "*I did that for the sake of variety, to make them all different*"
- e. 12, p. 8 – "*I wanted to visually connect the blocks*"
- e. 12, p. 10 – "*I wanted to make something different but then why would I? So I made it this way, it's more colourful*"
- e. 13, p. 8 – "*I wanted to keep the distances between notes with similar things… to keep the feeling*"
- e. 13, p. 15 – "*A B A B, a jumpy thing*"
- e. 14, p. 8 – "*I wanted to keep some similar elements across blocks*"
- e. 14, p. 20 – "*like experimental music, with no repeated notes… block 2 has no notes from block 1*"
- e. 15, p. 11 – "*seems like a Mexican thing* [sings La Cucaracha], *similar rhythm*"
- e. 15, p. 17 – "*links smoothly, block 4 has some resolution*".

The narratives were fairly simple, often comprising no more than one clause. This was expected, since the melodies were not very long to begin with – between 3 and 4 blocks.

- e. 8, p. 14 – "*a children game*"
- e. 8, p. 12 – "*merrily strolling, seeing things*"
- e. 9, p. 17 – "*Red Riding Hood going to see granny*"
- e. 9, p. 18 – "*emotions erupting while normality goes on*"
- e. 10, p. 14 – "*reminds me of Zeke Wolf that sneaks close to the three pigs*"
- e. 11, p. 12 – "*flows nicely, kind of a daily routine*"
- e. 12, p. 12 – "*day routine with distractions and things that go wrong along the way*"
- e. 12, p. 17 – "*It's a clown trying to find balance to the centre of the stage, a quizzical walk*"
- e. 13, p. 12 – "*a silly walk*"

- e. 15, p. 12 – "*kind of a chase, like cat and dog, fox and hound*"
- e. 16, p. 12 – "*not very happy, going up, then coming back, like mountains*".

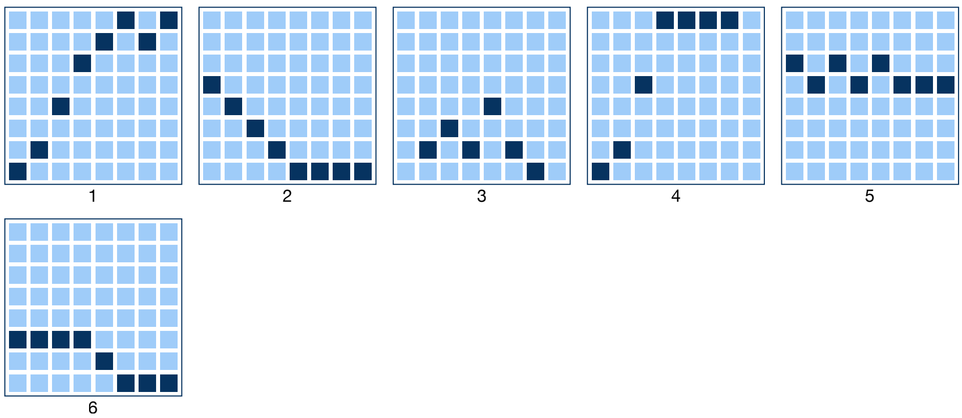
In summary There were no clearly prevalent strategies for composing the missing bars. Working with visual patterns was one of strategies that was often used in composing both similar and contrasting segments, although it felt like "*a weird way of making music*" to some, and many found themselves replicating identical patterns, although sometimes discarding their work because "*I'm copying the patterns, it's cheating!*". Although participants did not always voice their discomfort with copying patterns, or even entire blocks, they were often reluctant in confirming their choice to the tutor, and allowing themselves to progress through the exercise. The tutor had to reassure these participants several times that replicating patterns was a perfectly acceptable way of working in music.

Around turn number 12, some participants started looking tired – "*I give up on this one*", "*I'm going randomly!*" – and growing frustrated – "*oh, I want that* [missing] *note!*"– expressing discontent with their work – "*Gaah! That's horrible!*", "*I didn't like the first one so I changed my mind*" – and even loss of focus – "*I lost it, I don't know what I'm doing*", "*I'm having troubles with* [block 3]". Two participants chose to skip some of the last presentations of the fill-the-gaps exercise, and three other participants asked to interrupt their sessions. Two of these three participants said that they had lost interest in the session, and one mentioned previous commitments.

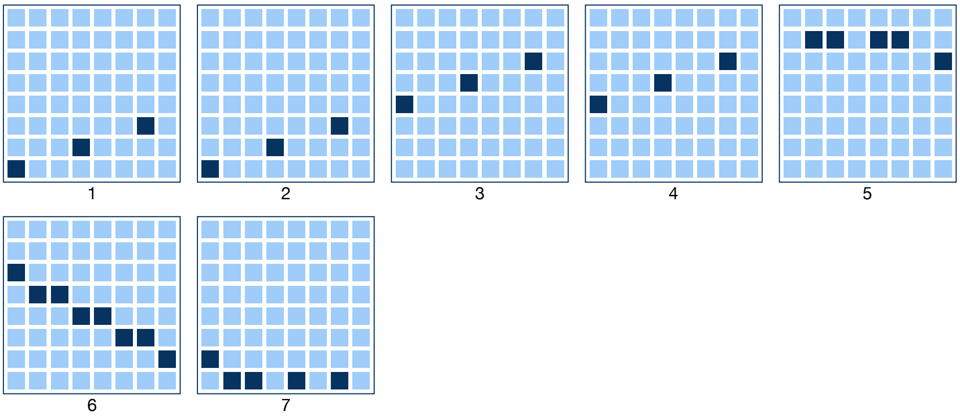
5.5.5. Storytelling exercise

Twenty-one participants completed the final composition exercise, in which they were asked to invent a short story, or a scene, and describe it by composing a melody. However, only fourteen participants provided a story to go with the melody, therefore only these were considered in the analysis. All the participants were encouraged not only to create a general feeling for the story with their music, but also to create different sections related to different parts of their stories. Not all the 21 participants produced melodies that incorporated this suggestion, nor were always able to explain which part of them related to which part of their story, but the 14 who did, did so in a clear and convincing way. Analysis of the individual sessions revealed that the participants who did, showed high interest through the entire session, and, save for one, reported being likely to try to make original music in the future. The following is a brief overview of these 14 melodies.

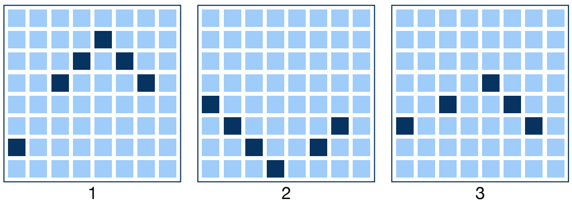
Participant 1 "*factory works: repetitive, scheduled*" — There are three pairs of similar blocks, symbolising different scheduled, repeated activities, arranged somewhat randomly. The participant indicated the first block to be similar to the fourth block, the second block to be similar to the sixth, and the third block to be similar fifth. The three pairs were meant to be different to indicate different activities. The strategy, as explained by the participant, was to first create pairs of blocks that resembled each other visually, and then modify them after listening to them, in order to make them musically pleasing.



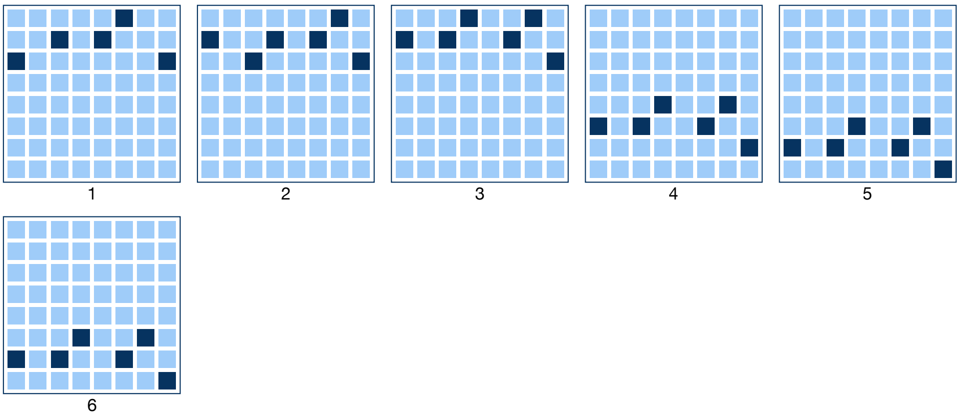
Participant 2 *"building up anticipation for a big event, which blows up and there is disappointment"* — The participant indicated that the first four blocks, with their continuously raising melody, represented the anticipation building up as the event approaches. The last three blocks instead represent the sense of disbelief (block 5) and discontent (blocks 6 and 7) when the event failed to live up to the expectations. The melody is clearly divided in two parts, in which block 5 represents a tense moment separating the first part, with a positive outlook, from the second part, with a negative outlook.



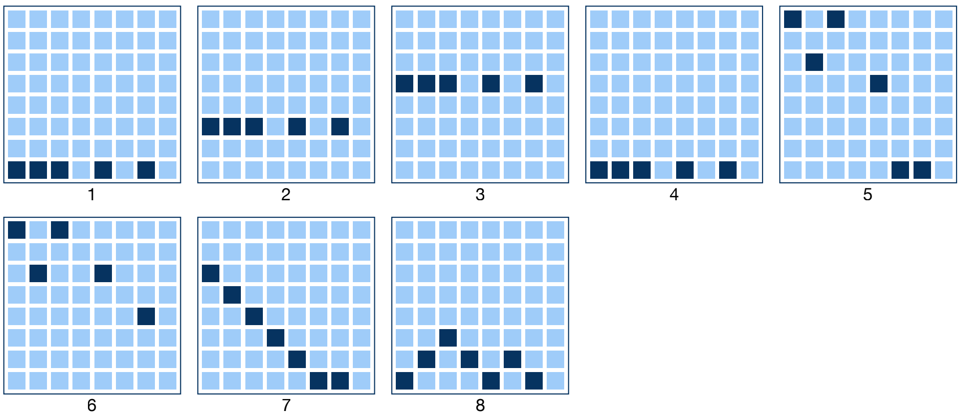
Participant 6 "*moving into a new house: very excited, very tired; mood back to normal or even worse (bad things happen); back up again*" — Each block was mapped by the participant to the three parts in the story: the first block represented the excited move into a new house; the second block represented the aftermath of the move, in which things did not go exactly as planned; the third block represented returning to everyday life, in a neutral situation. The participant explained that the height of the notes was mapped to the mood of each part: higher notes meant happier, busier, more excited moods, lower notes meant negative moods, and the middle notes in block 3 were meant to represent a neutral mood.



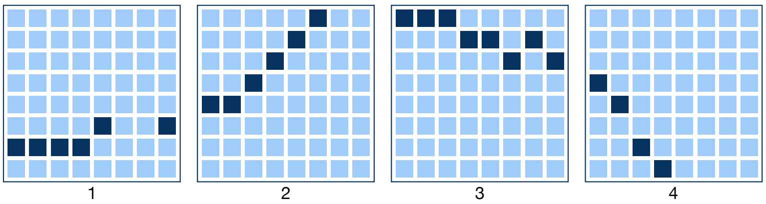
Participant 7 *"story of a funeral"* — The participant explained that the first three blocks, being high pitched and rather busy, were meant to represent people sadly going to a funeral, trying to keep their spirits high, but struggling. The last three blocks, with their lower pitches, were associated by the participant to the moment where everybody arrives at the function, the priest says prayers and blessings, and the coffin is laid in the ground. The participant explained that the height of the notes was mapped to the mood of each part, but also the short 2- and 3-notes figures represented the state of the people attending, constantly trying to keep their spirits up, but failing.



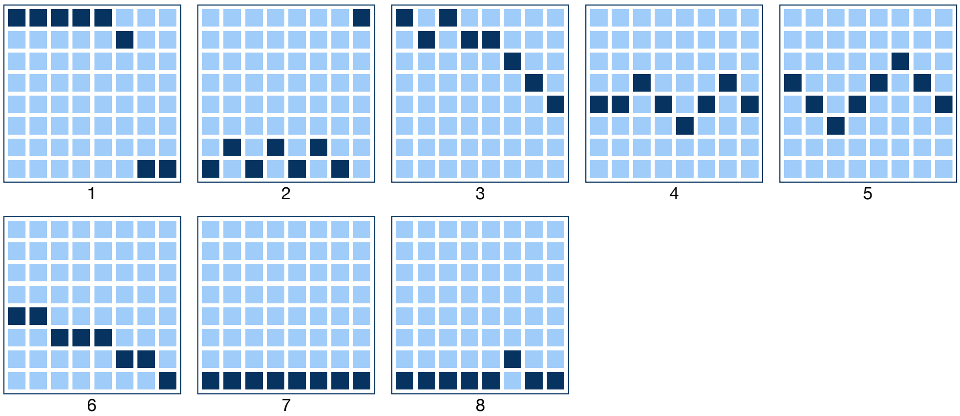
Participant 12 "*slow majestic entrance of an important person among a silent crowd, then people explode in cheers, then the person sits and makes everyone quiet*" — The participant clearly pointed at the blocks on the DTMI while describing the mapping between the melody and the story. The first four blocks represent the majestic entrance of the important person in the story – "*perhaps a king or a high dignitary*" – and his slow walk across the room, among the silent crowd. In particular, the fourth block was indicated as the moment in which the important person reached his destination and turned around towards the crowd. Blocks 5 and 6 were mapped to the moment when the people "*explode*[d] *in cheers*", and blocks 7 and 8 were indicated as the moment when the person "*sits and makes everyone quiet*". The strategy was to compose different themes for different moments in the story. In particular, the participant explained looking for a "*monotonous, yet uplifting feeling*" for the majestic walk, and "*a more exciting and random melody*" for the cheering part, "*and then back to the important guy*" with the last two blocks.



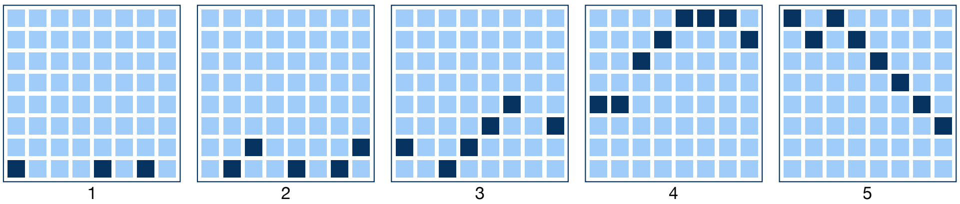
Participant 14 "*a squirrel sees an acorn and looks around, fetches it, fakes hiding it somewhere and then hides it somewhere else*" — The four blocks were mapped by the participant directly onto the four clauses of the story: in the first block, the squirrel sees the acorn and looks around to make sure no-one else has seen it; in the second block, the squirrel runs to fetch it, and searches for a place to hide it; in the third block, the squirrel spots a place and goes there, then fakes hiding the acorn, and then runs to another spot, finally hiding the acorn there. The participant explained the composition strategy as "*visual, resembling the movement of the squirrel*".



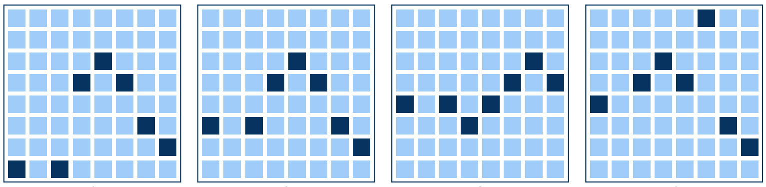
Participant 15 "*my commute home*" — The participant only vaguely explained how they related to the commute in the story. In particular, the participant explained that the pitches matched how much she enjoys each part of the journey – for example the first block was mapped to a bus ride to a train station, and the second block was mapped to the subsequent train ride, deemed less exciting and enjoyable than the bus ride because less scenic and more monotonous. Blocks 3-6 were not explicitly mapped to anything in particular, but just described as "*the rest of the journey, walking, underground*". Lastly, blocks 7 and 9 represented arriving at home, and settling for the evening, with "*usually not very exciting activities*".



Participant 16 "*this is the story of my son who wakes up every morning, then comes wake me up*" — The participant explained that she composed the blocks based on her level of awareness that her son is awake at any moment. In this light, the participant mapped the first two blocks to the son quietly moving in his bed (block 1) and stepping down from it (block 2). The third block was mapped to the son entering the parents' bedroom, and shaking the mother until she wakes up. Block 4 was described as "*my realisation that I have to leave the bed*", and block 5 was "*us going downstairs to make breakfast*". The participant explained that she mapped not only the height of the notes to her level of awareness, but also the number of the notes, implying that more notes and less pauses meant increased awareness. However, the last block was explicitly described as "*not that I'm less aware of it, it's just we go downstairs*", implying that, in that block, she also used contour to describe the scene.

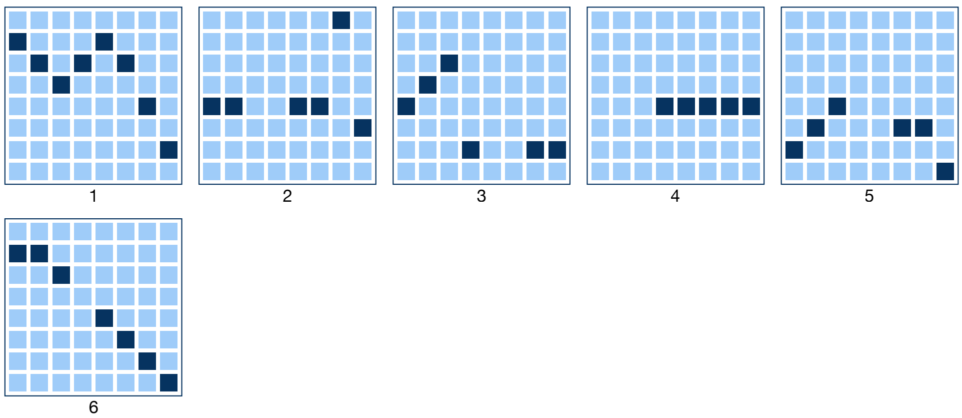


Participant 17 "*Escher walking around and finding himself*" — The participant described the melody as "*cyclic, constantly moving back and forth, and going back to where it started, but in different ways*". The participant explained that, through subtly changing an otherwise repetitive pattern, the melody was meant to represent the intricacies and surprising loops of M. C. Escher's works.

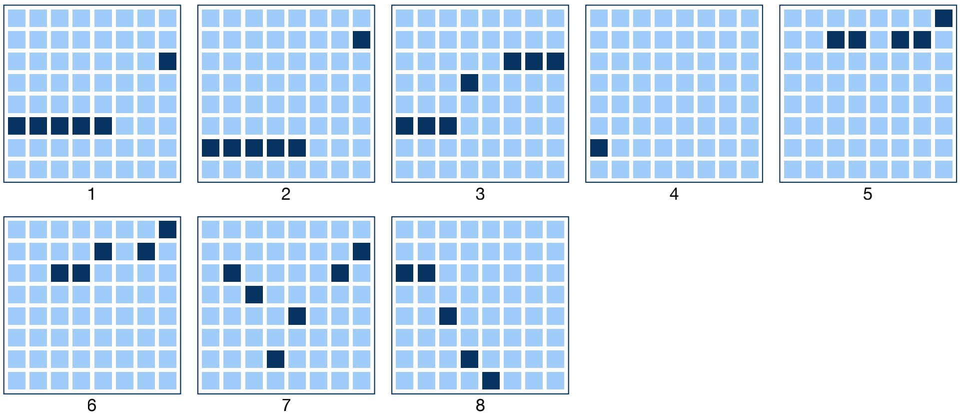


1 2 3 4

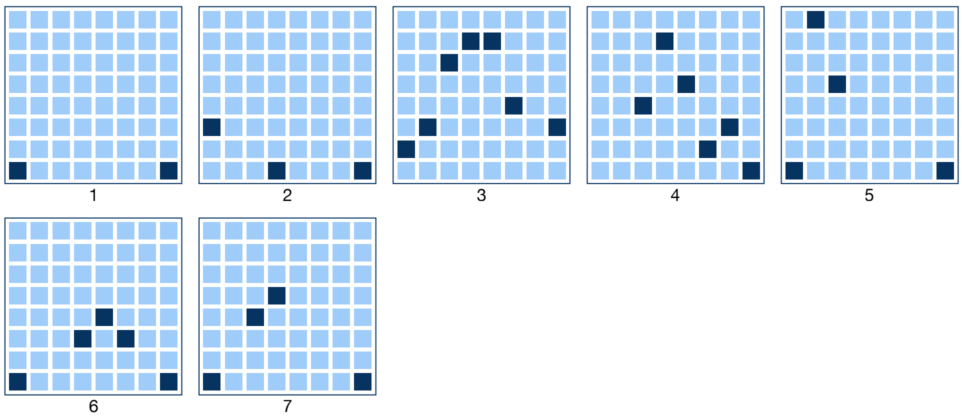
Participant 19 "*a guy is driving, the car breaks, then starts again, coughs a bit, then goes down a slope*" — The participant mapped the melody quite clearly to the story, by pointing at each block on the DTMI while explaining the connection. In the first block, the person is driving, but the car breaks in the middle of block 2. The driver restarts the car and drives into block 3, where the car starts coughing, and keeps going like that through blocks 4 and 5. Lastly, in block 6, the car "*goes down a slope*", marked by the descending melody, only interrupted by one last cough. The participant commented that he was trying to convey the sense of tension and uncertainty that the driver got when the car started acting wrongly. Then, in the last block, the participant explained that he was looking to replicate "*that cartoon effect when you fall quickly, you know the whistle*".



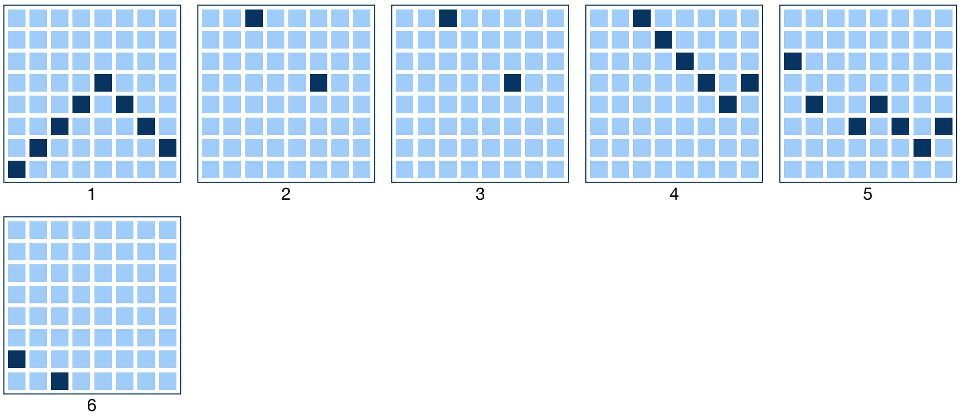
Participant 20 "*mice stealing cheese*" — The participant said that she started composing with another story in mind – "it's starting to feel like a crime story, like someone sneaking on a rooftop, maybe a bank. Let's see if I can do something like rushing, like police cars". However, after realising that she could not find the right, tense notes – "can't find police, here" – she decided to change the story to a less dramatic, more comical story. The participant explained that the first four bar represented someone sneaking somewhere – first a thief, but later mice heading for cheese – followed by bars 5 and 6 in which the theft is accomplished, followed by blocks 7 and 8 in which the mice run away with the stolen cheese. The participant did not explain the strategy in composing the melody.



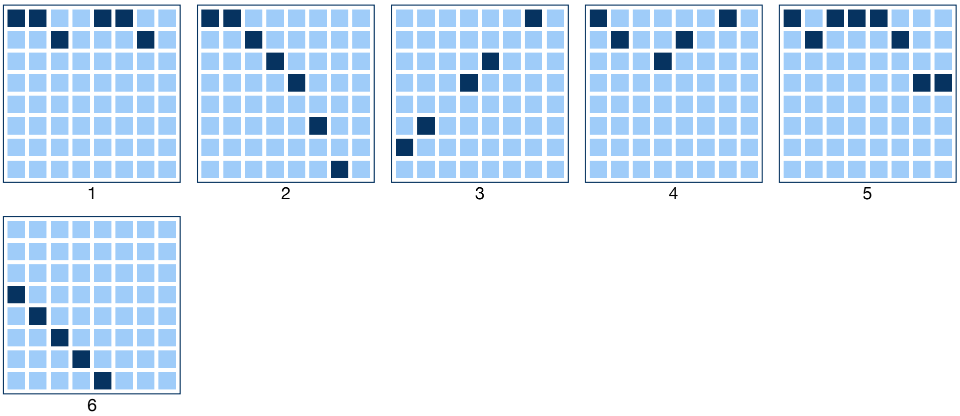
Participant 21 “*the snow child, when the old lady is sad because she doesn’t have a child, so she looks out of the window and sees a snow child, so she’s happy, but then she’s sad again because she can’t let him in or he’d melt*” — The participant explained that, in the blocks, “*there are the two notes in the lower corners, those represent the sadness of the lady*”. In fact, according to the participant, the second block has a higher note instead of a low note in the corner, and that is the moment when the lady spots the snow child outside of the window, and cannot believe her own eyes. In blocks 3 and 4, the old lady becomes happier, and this is reflected in the livelier melodies, “*with all those high notes, but then she realises that she can’t let the child in*”, in block 5, and so “*they just stare at each other through the window, waving their hands*”. Blocks 5-7 return to represent the sadness of the lady with the low Cs in the first and last slots.



Participant 23 "*school child walking after school, spotting things along the way*" — The participant mapped the melody in this way: blocks 1, 4, and 5 represented the child getting out of the school gates, walking home; blocks 2 and 3 represented the child "*spotting things along the way*"; block 6 is the one in which the child arrives at home. The strategy, as explained by the participant, was to represent the different states – walking, spotting things – with "*different rhythms*".



Participant 24 "*a guy's alarm clock goes off in the morning, wakes up, goes down for coffee, and goes about his life*" — The participant explained that he was trying to compose each block different from the others to represent a different moment in the story. Block 1 was explained as the sound of the alarm clock, "*repetitive, high pitched*". Block 2 represented the person waking up and going downstairs to make coffee, "*his mood is plummeting as he waits for the coffee to brew*". In block 3, the person finally drinks his coffee, represented by the melody going upward, "*but with pauses, like in the next block, things are slow in the morning*". Block 4 represented the moment when the protagonist starts his day, still slowly – "*I kept the rhythm in the previous block*", leading to the finale in blocks 5 and 6 in which, finally, the person "*goes about his life*". The strategy, although not explicitly mentioned by the participant, is similar to what other participants did with mapping the mood to the height of the notes in the melody.



Summary

Of these 14 participants, 9 were considered beginners, and 5 non-beginners, according to the criteria stated earlier in the chapter, and they all declared that they had never composed music before. One non-beginner reported not being more likely than before to try to compose original music in the future, whereas all 9 beginners, and 4 other non-beginners, reported being more likely than before by 1 point on a 5-level scale. This would suggest that the session may have had some impact on their self-confidence, by providing them an easily approachable way of making music.

The strategies adopted by the participants were classified into four categories

- **mood**: mapping the evolution of the mood to musical parameters;
- **themes**: associating different themes to different parts of the story;
- **visual**: drawing shapes reminiscent of the events in the story;
- **variations**: applying variations to otherwise repetitive patterns.

Table 5.8a summarises the strategies used by the fourteen participants that were included in the analysis of the storytelling exercise. Table 5.8b summarises how many times these strategies were used by the fourteen participants. The sum exceeds the number of melodies that were analysed because some participants used multiple strategies.

5.6. Discussion

The study presented in this chapter investigated how a DTMI could be used to allow musically inexperienced people to explore profound musical concepts, such as creating structure and narrative in a melody through similarity and contrast.

5.6.1. Designing DTMI-supported learning sessions

The session protocol was designed as a learning session, in which a tutor (the researcher) introduced the concepts to a student (the participant) by going

participant	**strategies**
1	themes, variations
2	themes
6	mood
7	mood
12	mood, themes
14	visual
15	mood, themes
16	mood
17	variations
19	mood, visual
20	themes
21	mood
23	themes
24	mood

(a)

strategy	**count**
mood	8
themes	6
variations	2
visual	2

(b)

Table 5.8. Summary of the music composition strategies used by the participants

from a general discussion of the topic, to a series of focused exercises that would provide evidence of the participant's ability to apply the concepts in practice. The findings suggest that a session designed in this way allowed participants to explore new concepts in an enjoyable and comfortably paced way, by affording them the ability to experiment with the musical concepts using an intuitively usable DTMI. This study provided evidence that the DTMI that was developed is a viable educational tool to support learning of less-than-trivial musical concepts. Furthermore, it provided an example of how such technology could be incorporated in a tutoring session.

It is important to note that, for some participants, the sessions were too long, and led to drop out. This must be taken into account when designing learning sessions of this type, and learning sessions in general: it does not matter how much participants are enjoying themselves, as in reality people can only remain continuously focused for relatively limited time spans. Although the length of the session was considered reasonably short at design time, some participants started looking tired and losing focus toward the end. This may suggest that the content and mechanics of the session – involving constant discussion, and standing up for around 30 minutes – were too demanding, and the design may need to be re-visited – perhaps by shortening the running time, or including breaks.

Lastly, one-to-one sessions in music education are often devoted to studying and practicing technique, and other aspects of instrument playing, rather than exploring broad music theory and composition concepts. A group setting is arguably more suitable for such activities. The next chapter reports on a study investigating how a group of people used a DTMI to support them in exploring the same topic as in this chapter.

5.6.2. Criteria for similarity and contrast in melody

Part of this study was to understand the criteria that participants used in assessing similarity and contrast in melody, prominent among which are contour and rhythm; but expressivity and mood played a part, particularly in determining dissimilarity and contrast. The listening and classification, and the challenge-response exercises provided evidence of how these criteria were identified by the participants, with the aid of a tutor, and used in composing melody. The use that participants made of these criteria in responding to simple challenges, and how participants made sense of them by explaining their work, was also analysed. This provided evidence that participants became increasingly aware of how these criteria could be used in suggesting a narrative with melody. However, not all participants were always able to explain how they used these criteria. Although results varied in terms of the clarity with which participants explained their use of similarity and contrast, in reality the storytelling exercise showed that 14 out of 24 participants were aware of the idea that similarity and contrast can be used to suggest narrative in music, and that can be considered a positive outcome.

5.6.3. Composing music with narrative

The use of similarity and contrast in composing melodies that suggest a narrative was further examined in the analysis of the storytelling exercise, presenting an overview of the work done by 14 participants. The participants explained how they mapped their melodies to the stories that they invented, and what strategies they used in composing the melodies. From this, four main strategies were identified, showing the ways in which participants worked, and providing evidence that they were able to use the musical concepts, discussed during their sessions, to compose a melody that suggested a narrative. It is true that only 14 out of 24 participants were included in the analysis of this exercises, but in reality only 21 of the original participants completed their session, and 7 of these did not relate their melodies to a story, nor were able to explain their process, therefore were considered only partly successful. However, if we factor in that none of these had composed original music before, and that their confidence was quite low, the exercise was indeed successful for them, and generally successful, as 14 participant represent two thirds of the 21 participants that completed their sessions. On the other hand, of the remaining ten participants, four stated that they had composed music more than once before, and they were generally more confident, as is shown in table 5.9. This may suggest that the way in which the session was designed, and possibly the simple music that the DTMI allowed, posed too little of a challenge to less inexperienced participants, therefore making them lose interest.

	1	**2**	**3**	**4**	**5**
completed	**9**	5	0	0	0
not completed	2	**5**	3	0	0
total	**11**	10	3	0	0

Table 5.9. Participants' confidence in their ability to make original music, by session completion status

5.6.4. Limitations

Three participants interrupted their sessions, one because of other commitments, and two because they did not want to proceed further. In addition to this, some participants decided to skip some of the final exercises, and proceeded to the storytelling one, and to the conclusion of the session. Post-session questionnaires were presented to all the 24 participants, and did not show that the participants who dropped out or skipped parts had a bad experience overall – cf. table 5.3, items Q5 and Q6, indicating average-to-high enjoyment and concentration.

Furthermore, it became clear that the post-session feedback questionnaire could not capture sufficient nuances to provide an accurate assessment of the participants' experiences in the study, therefore a revised and expanded questionnaire was developed for Study 3, reported in chapter 6.

5.7. Conclusion

This study provided evidence to answer the questions stated at the beginning of the chapter.

SQ 2.1. The participants developed ways of talking about similarity and contrast in melody. Several criteria for similarity, difference, and contrast, as well as ways of reasoning about these, emerged from the discussion that involved the participants and the researcher. Among the criteria for similarity, the participants identified melodic contour as the top factor. Contrast was instead judged mainly using three different dimensions: mode, rhythm, and expressivity. The participants identified two relations between similarity and contrast (i) in the number of dimensions along which comparisons can be made, and (ii) in the necessity for these comparisons to be reasonably meaningful.

SQ 2.2. The storytelling exercise at the end of the session was considered successful for 14 out of 24 participants. This showed that the majority of the participants became aware of the role of similarity and contrast in suggesting narrative in melody, and could use it to compose and discuss their work.

SQ 2.3. The storytelling exercise, along with the various music composition exercises, showed that all the participants were able to compose music that was meaningful for them using the DTMI. This suggests that the DTMI provided adequate support for beginners, and non-beginners, to compose music.

SQ 2.4. The participants generally reported having enjoyed their sessions, although some had to skip parts in order to accommodate previous commitments. Neither the feedback questionnaire, nor the researcher's notes, report signs of prolonged stress, except for occasional tiredness – suggesting that the sessions were too long for how they were designed – and occasional nuisances – mainly due to quirks of the DTMI's.

The evidence presented in this chapter suggests that the DTMI was overall adequate as a tool to support the discussion and use of musical concepts. We can also conclude that careful design of educational activities around digital tabletops is of critical importance in influencing the experience of the students. In particular, more frequent breaks could have been included in this study, providing pauses of reflection, and rest for the participants who mostly stood on their feet while working with the DTMI.

6 A group study of similarity and contrast

The exploratory study described in this chapter covered the same topic as Study 2 – the role of similarity and contrast in suggesting narrative in melody – but investigated how groups of people of mixed musical experiences discussed the topic, and how they used the DTMI to support their discussion. Study 2 showed that the DTMI was an adequate tool for students to explore the concepts of melodic similarity and contrast to suggest narrative, with the aid of a tutor. This study covers the same topic, but with groups of participants of different levels of experience, and without the aid of a tutor.

6.1. A Computer-Supported Collaborative Music approach

One-to-one sessions in musical training are often better suited to practising technique. Conversely, group settings may be more suitable for tackling higher-level concepts, such as musical analysis and composition strategies, which can benefit from multiple points of view.

The literature on CSCM systems in general is well established, and a good review of the field is provided by Xambó (2015). However, the use of CSCM systems in education is still under-researched, as discussed in chapter 2. In particular, the research done by Xambó (2015) suggests that CSCM systems, and tabletops in particular, are promising for allowing groups of mixed musical experience to discuss and practise musical concepts at different levels of detail and abstraction.

Studies 1 and 2 suggested that an appropriately designed DTMI can provide adequate scaffolding for people to discuss musical concepts of different complexities. The DTMI provided a powerful transformational representation that was easily accessible by novices and experts, and that provided them with a discussion focus and record of decisions. This was achieved by representing aural objects graphically, by allowing direct manipulation of these objects, and by providing immediate feedback on such manipulations.

By focussing on these aspects, this study investigated the role of the proposed DTMI as a mediator in a group discussion about melody. In particular, this study had a group of participants, of different levels of musical experience, explore the role of similarity and contrast in composing melody that could suggest a narrative. The aim was to investigate how they used the DTMI to discuss the concepts, and collaboratively compose a piece of music to tell a story.

6.2. Research Question

To understand the role of the DTMI in supporting a group discussion, as well as to understand the group dynamics of a discussion mediated by a DTMI, this study was designed to answer the research question stated in chapter 1. In particular, it explored the role of melodic similarity and contrast in suggesting a narrative, and addressed the following sub-questions.

SQ 3.1. What are the criteria by which the participants judge similarity and contrast in melody? How do they relate the two concepts?

SQ 3.2. How do the participants understand the role of similarity and contrast in creating structure and suggesting narrative in melody? What strategies do they use in composing a melody that tells a story?

SQ 3.3. How do the participants use the DTMI as a mediator for discussing melodic similarity and contrast?

SQ 3.4. Does the DTMI provide an enjoyable experience, favouring concentration and learning, or does it create undue stress?

It is important to stress that this, as well as the previous studies, was an exploratory study. The role of DTMIs in music education has been sparsely researched, and so this study aimed to be a step toward more systematic research in the field (Dillenbourg et al., 2011).

6.2.1. Forms of evidence

The following list derives from the research question and sub-questions stated above.

Developing criteria for similarity and contrast in melody (SQ 3.1)

The sessions were video recorded entirely – from the initial discussions on similarity and contrast, to the explanations that the groups gave of the melodies that they composed. This provided a record of how the participants discussed similarity and contrast – both in general and in melody – and how they developed ways of thinking about these concepts. The conversations provided insight into the participants' initial definitions of similarity and contrast expressed in general terms, and identified the criteria that they used in judging these two concepts. During the course of the session, the conversations provided evidence of how the participants developed criteria for determining similarity and contrast in melody. Application logs recorded the melodies that were produced during the course of each session. This provided a record of the musical choices that the participants made. Analysing the melodies provided additional evidence of the criteria that were used, and how, in composing melodies using similarity and contrast.

Use of similarity and contrast in suggesting narrative in melody (SQ 3.2)

The participants were asked to explain the relation between the stories and the melodies that they composed during their sessions, and these explanations were video recorded. The ability of the participants to explain such relations, and the ways in which they did so, were considered evidence of how they learned to use similarity and contrast to discuss and compose melodies that suggest narrative. Further evidence was provided by the musical examples that participants produced and discussed throughout the sessions.

DTMI as a discussion mediator and educational tool (SQ 3.3)

Video recordings provided evidence of how the participants used the DTMI to support their discussion. Analysing whether, and how, participants used the DTMI in discussing examples of similarity and contrast in melody, and in performing the composition challenge, provided further evidence regarding the role of the DTMI as a discussion mediator.

Stress, enjoyment, and concentration (SQ 3.4)

A revised feedback questionnaire – described in section 6.4 – was used in this study, and participants were offered a debriefing discussion to complement the questionnaire and record any additional comments or insights. Non-verbal communication was recorded on video, and was considered to provide additional evidence of stress or enjoyment. The combination of these with the feedback questionnaires and debriefing discussions were considered evidence of how enjoyable or stressful, easy or difficult the participants perceived the sessions to be.

6.3. Study design

Groups of three participants with mixed levels of musical experience were involved in this study. All the groups comprised participants that were considered beginners, and people who were either non-beginners, or returning from participating in Study 2 – and who were therefore familiar with the DTMI and the subject of the study, or both. This intentional mixing of experience levels was done to understand whether different experiences within the groups would affect the way in which the groups discussed, in particular, whether beginners would be encouraged to contribute, or instead be intimidated, by the presence of an "expert".

6.3.1. Protocol

The following is a brief outline of the typical session. An explanation of the session and its main objectives was offered to the participants before the session began.

1. **Demographic questionnaire**
2. **Discussion** of similarity and contrast in **general terms**
3. **Discussion** of similarity and contrast in **musical terms**, using the DTMI
4. **Storytelling exercise**
5. **Post-session questionnaire** and (optional) debriefing.

The participants were informed that they were allocated roughly twenty minutes for both discussions – general and musical – and fifteen minutes for the storytelling activity. It was also explained to them that this schedule was flexible, and that they could take as much or as little time as they felt necessary, on the condition that the whole session would not run longer than sixty minutes. The transition between each activity was left entirely to the group, although the researcher reminded the participants of the time every ten minutes.

Session activities

The following is a detailed description of a typical session.

Demographics questionnaire At the beginning of the session, participants were asked to complete a questionnaire regarding their musical background, and their confidence in their ability to make music. This questionnaire was identical to the demographics questionnaire used in Study 2, and it was analysed in the same way. The questionnaire can be found in appendix D, and all the answers to the questions requiring a ranking were on a 5-level Likert scale.

General discussion The first part of the discussion was intended to introduce the participants to the subject of the session – similarity and contrast. This was to allow the participants to discuss their definitions and ideas of similarity and contrast in general terms, and to allow them agree on a set of criteria for determining these. The purpose of this activity was to make all the participants aware of each others' points of view, and to develop a set of criteria for similarity and contrast that they all agreed upon, so that they could use them as a guide through the session.

Musical discussion In this activity, the participants were free to use the DTMI to carry on their discussion on similarity and contrast in the context of melody. The purpose of this activity was to see how the groups used the DTMI as a tool for mediating and supporting their discussion. The groups who were hesitant or uncertain as to how to proceed were given a few options by the researcher. For example, it was suggested that each participant could produce pairs of short melodies, explain to the group why they thought of them as similar or contrasting, and take the conversation from there.

Storytelling The transition to the storytelling exercise was marked by clearing the DTMI of all the blocks left after the previous discussion. The purpose of this exercise was to see how participants used their previous discussion in developing a narrative and translating it into music. When the group was done with composing the melody, participants were asked to explain their choices, and how different parts of the story and the melody related to each others.

Debriefing and post-session questionnaire A short debriefing was offered to participants, following up on their work on the last exercise. This was to allow them to discuss their work with the researcher, as well as to reflect on the choices that they had made, and on the criteria they used to establish narrative in the melody. Lastly, participants were handed a feedback questionnaire in order to assess their experience.

6.3.2. Configuration of the DTMI

The participants were allowed to use the DTMI freely in order to discuss the topic. The DTMI developed for the first study was configured to allow multiple blocks to be used, and the blocks were configured to present 8 divisions on the horizontal axis, and a C major diatonic scale, extending between MIDI C_3 and C_4. Participants were allowed to create as many blocks as they felt necessary for the purpose of discussion. For the storytelling exercise, the configuration of the DTMI used during the discussion was left unaltered so that participants would find a familiar environment.

6.3.3. Handling of participants

Participation in this study was voluntary and anonymous, and involved participants who were willing to improve their music appreciation skills. The background skills of the participants were assessed individually through a self-evaluation questionnaire in order to provide some context when analysing their sessions. Participants were recruited with the same criteria used in the previous study – any musical background, and willing to improve their music appreciation skills – and those that received music education for two or fewer years were considered "beginners". Here, music education generally meant compulsory music classes, typically attended several years in the past, as discussed in section 4.3.2. Participants returning from the previous study were welcome to participate in this study as well, and care was taken so that at least one new participant was present in every group.

6.4. Methodology

6.4.1. Video recordings

All the sessions were video recorded, except for one in which one participant preferred to not appear on video – but instead agreed to audio recordings. In that session, notes were taken by the researcher to record group dynamics, gestures and non-verbal communication, and so on.

6.4.2. Revised feedback questionnaire

The post-session feedback questionnaire was modified, since it was found not to have been entirely effective at capturing nuances of participants' experience in the previous study. The modifications aimed at expanding the statements in the previous version, and the new items were generated, and grouped, using the themes **Discussion**, **Outcome**, **Interface**, and **Engagement**. These four themes are explained below. The items regarding engagement were partly inspired by the discussion by Moneta (2012) of the Flow Questionnaire and on the *Experience Sampling Method*. It is worthwhile noting that the aim was not to investigate or measure Flow, but rather to produce a questionnaire that could yield more nuanced insights to inform the analysis of the sessions.

The case of items A3.1 and B25 is particular: these inquired about participants' confidence in their ability to compose original music. The statements are formulated differently. A3.1 – "*How confident are you in your ability to compose original music?*" asked to check one of five possible answers, from "not at all" to "a lot". B25 – "*I am confident in my ability to compose original music*" – asked to check one of five possible answers from "strongly disagree" to "strongly agree". Because of these differences, comparing them may be problematic. Furthermore, while rating item B25, participants were not comparing their answers with those that they gave to question A3.1. This was because the pre- and post-session questionnaire were presented separately to the participants; therefore it is a weak assumption that a variation in their answers represents an actual variation in their confidence.

The full revised questionnaire can be found in appendix D.

6.4.3. Thematic analysis of the feedback questionnaire

The post-session questionnaire was generated using the following four themes, and the participants' answers were analysed accordingly to provide evidence to answer SQs 3.3 and 3.4.

Discussion (Di), to investigate the participants' satisfaction with the discussion.
In particular, this theme investigates whether the participants thought

that the discussion helped them to understand the role of similarity and contrast in suggesting narrative in melody.

Outcome (Ou), to investigate the participants' satisfaction with the melodies that they composed during their sessions (musical outcome), as well as their confidence in their ability to compose original music, and the likelihood that they will do so in the future (personal outcome).

Interface (In), to investigate the participants' opinion of the DTMI: its usability, and its role as a discussion mediator, and music composition platform.

Engagement (En), to investigate the participants' feelings regarding their sense of involvement in the collaborative work, and the ease of discussing melody with the group using the DTMI to compose example melodies.

6.4.4. Thematic analysis for collaboration

Video and audio recordings were also analysed using the themes described above, in order to investigate how the groups behaved during the sessions, and what were the strategies that they used in the discussions (SQs 3.1 and 3.2). In addition to those, the following themes, inspired by Bryan-Kinns et al. (2012) and (Hornecker et al., 2006), were used to analyse the video recordings.

Mutual Awareness (MA), to see if all the participants were aware of who contributed what to the group activities, and how participants made use of new information. Aspects that are analysed within this theme include:

- the ability of all the users to become aware of who is contributing what to the collaboration;
- the ability of all the users to see what is happening with the system.

Mutual Modifiability (MM), to see if all participants were able to modify each others' contributions, and if they did so in an egalitarian or hierarchical way. Aspects that are analysed within this theme include

- the ability of all the users to see what is happening with the shared objects;

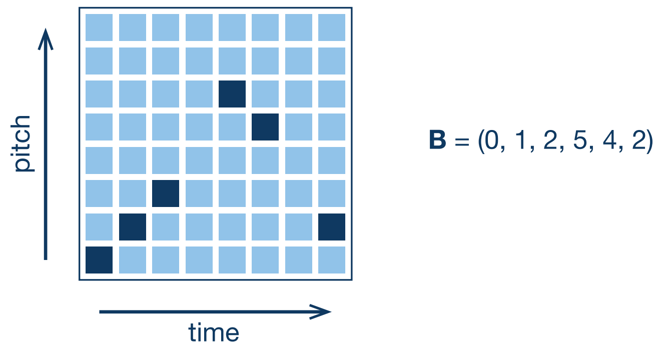


Figure 6.1. Left: block representation, extracted from the applications' logs. Right: array representation.

- the ability of all the users to access and manipulate the central objects of interest.

Externalisation (Ex), to see if participants were able to use the shared objects as a focus for discussion, and to investigate the capacity of such shared objects to provide a significant representation of the concepts being discussed. Aspects that are analysed within this theme include:

- the ability of the users to think and talk through the objects;
- the ability of the objects to provide a focus for, and a record of, the users' discussion.

6.4.5. Storytelling melodies

The analysis of the melodies produced during the storytelling exercise was mainly based on the explanations that participants gave of how they thought that the story mapped onto the melody, with the same intention as the exercise in Study 2. As the melodies were analysed in the form of sequences of blocks three metrics were computed, block by block (see section 3.4.3 and figure 3.8 for an explanation of the blocks). Blocks were considered arrays of length 8 – along the time axis – containing values between 0 and 7 – corresponding to the active squares in each block (figure 6.1). For simplicity, pauses – missing notes – were not considered in any of the measures listed below.

Mean

To compute the mean of a block, discrete values were considered points in a continuum, therefore the mean has a decimal part, and thus has no musical meaning. The mean of each block was considered to provide a sense of "big picture" contour – i.e., how the melody moves up and down at a block level, rather than at a note level.

Shannon Entropy (H_i)

Each block B_i was treated as a discrete random variable, so that Shannon's entropy could be computed. Entropy was considered as a measure of "liveliness" or "idleness" of each block. Standard deviation and entropy, as measures of how much pitch moves up and down, were found to correlate in most cases. However, entropy provided a better sense of how "lively" individual blocks were, as discussed in the analysis of group 5 in section 6.5.4. Therefore, it was decided to consider entropy instead of standard deviation as an indication of how much pitch moves up and down in a block. Shannon Entropy was computed using R's package '`entropy`' (Hausser et al., 2014).

Cross-entropy ($H_{m,i}$)

The use of cross entropy as a measure of contrast was proposed by Laney et al. (2015) based on the work of Pearce (2005). According to Laney et al. (2015), the cross-entropy can be used as a measure of similarity, or contrast, between two musical phrases. Here, cross-entropy was computed between pairs of blocks that form a single storytelling melody. In turn, each block is used to compute a model against which every other block in the melody is tested. The cross-entropy of block B_i against a model constructed using block B_m represents how likely it is that block B_i could be generated using the model as the basis of a 0^{th} order Markov chain. This process generated one matrix for each melody, in which the value in cell (m, i) – hereafter referred to as – is the cross entropy of block B_i computed against the model produced using block B_m. Since not all the notes are necessarily present in every block used to compute the models, a uniform probability was assigned to missing notes, and it was chosen small enough to avoid excessive distortion. The algorithm used for computing the cross-entropy is as follows.

Let $B_i = (b_1, \dots, b_n)$ be a block (cf. figure 6.1). Let q_m be the probability density function of block B_m. Since q_m could be 0 for some of the notes, p_m is defined as

$$p_m(j) = \begin{cases} q_m(j) & \text{if } q_m(j) > 0 \\ \varepsilon & \text{if } q_m(j) = 0 \end{cases}$$

(with $\varepsilon = 0.01$) and then used in computing the cross-entropy $H_{m,i}$ of block B_i using block B_m as a model as

$$H_{m,i} = -\frac{1}{n} \sum_{k=1}^{n} \log_2 p_m(B_i(k)). \tag{6.1}$$

For the purposes of identifying points of contrast along the natural flow of the melodies, the most relevant cells are those of coordinates $(m, m+1)$, representing blocks that are adjacent moving forward in the melody. Other cells can provide insight regarding the overall structure of the melody. It is worthwhile noting that the models considered in the present analysis are merely probability distributions, and so they only represent their probability of each note to appear in a block. Conversely, Laney et al. (2015) used Markov chains of order higher than 0 instead. This allowed the authors to consider sequences of notes, therefore making the temporal order of the notes relevant.

6.5. Findings

Twenty-four participants volunteered for this study, coming from staff available on the Open University campus, and were grouped into eight groups of three participants each. Care was taken so that every group contained at least one new participant, preferably two, although in one case this was not possible, and this group was composed entirely of returning participants. Based on video and audio recordings, the sessions lasted approximately between 36 and 61 minutes

years	participants
≤ 2	14
$3 \div 10$	9
≥ 11	1

(a) Duration of music studies (including none).

	participants
beginners	14
non-beginners	10
total	24

(b) Breakdown of the participants.

Table 6.1.

(mean = 48' 38", sd = 9' 27").

6.5.1. Demographics

The demographic data collected with the pre-session questionnaire are summarised in table 6.2. Fourteen participants had studied music for two of fewer years (A1.1, mean = 0.79 years, sd = 0.89 years) and therefore they were considered beginners according to the criteria explained above. The remaining ten participants received had studied music for 3 to 12 years (A1.1, mean = 7.2, sd = 2.78). A summary is provided in table 6.1a. Fourteen participants said that they played at least one musical instrument, although four of these specified that they had not been playing for years. Across the 16 participants who reported playing at least one musical instrument, the most reported skill on their best instrument was 3, with 15 of these between 1 and 3.

Fifteen participants said that they had never tried composing original music before (A3), eleven of these were among those considered beginners, and nine of the fifteen were returning from the previous study. The most reported answer to question A3.1 by both beginners and non-beginners was 1, meaning no confidence in the ability to compose original music. However, the answers given by the beginners were more concentrated around the lower end of the scale, whereas the answers given by the non-beginners were more spread out. Table 6.2f shows that the returning participants were more likely to report low confidence than new participants, regarding their ability to compose original music. This

	no	**informally**	**formally**
beginners	**7**	5	2
non-beginners	0	1	**9**
total	7	6	**11**

(a) A1: Have you studied music?

no	**one**	**more**
10	3	1
0	2	**8**
10	5	9

(b) A2: Do you play a musical instrument?

never	**occasionally**	**often**
11	3	0
4	2	**4**
15	5	4

(c) A3: Have you ever composed original music?

	1	**2**	**3**	**4**	**5**
beginners	**4**	1	1	0	0
non-beginners	1	2	**6**	0	1
total	5	3	**7**	0	1

(d) A2.1: How would you rate your skills on your best instrument?

1	**2**	**3**	**4**	**5**
8	5	1	0	0
3	2	2	2	1
11	7	3	2	1

(e) A3.1: How confident are you in your ability to compose original music?

	1	**2**	**3**	**4**	**5**
new	**5**	3	1	2	1
returning	**6**	4	2	0	0
total	**11**	7	3	2	1

(f) A3.1 by new/returning status

Table 6.2. Summary of the answers to the demographics questionnaires

may seem counterintuitive. In fact, one might expect that returning participants, who often declared an increase in their confidence in their ability to compose original music at the end of Study 2, would report values consistent with this increase. In reality, the two studies were separated by several months, during which time the participants probably had little chance to compose more original music, therefore the boost in confidence given by Study 2 may have faded over time. On the other hand, the answers in the demographics questionnaire given by the returning participants in this study were comparable to those that they gave in the same questionnaire of Study 2. Analysing the individual cases was not possible because the data from Study 2 were already fully anonymised at the time of the present analysis.

6.5.2. Feedback questionnaire (SQ 3.4)

Table 6.3 summarises the participants' self-assessment of their experience in the study. The table is referred to throughout this section. This section reports on the post-session questionnaires that will be used to inform the subsequent analysis of the sessions.

Engagement

Items B9 to B18 listed below inquired about feeling engaged and in control during the various activities, and feeling of contributing to the group work.

- B9. I felt in control during the discussion
- B10. I felt in control during the composition task
- B11. I felt that I was able to undertake the final composition challenge
- B12. I felt that I could contribute to the collaboration
- B13. I felt comfortable contributing to the collaboration
- B14. I felt that I was contributing a lot to the group work
- B15. I felt that my contributions were appreciated by the group
- B16. I felt that the final piece of music reflects the way in which the group worked
- B17. I felt it was easy to communicate my ideas and intentions to the group

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26
SD	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	9	0	0	0	0	2	4
D	0	1	1	3	0	3	1	2	4	2	0	1	1	5	0	1	2	4	9	14	0	1	1	1	10	3
N	3	6	8	9	3	7	2	2	7	6	5	5	3	8	6	4	6	3	5	1	3	6	8	5	2	8
A	14	14	14	9	17	9	12	11	12	14	14	14	13	10	13	15	15	13	2	0	17	11	12	15	9	7
SA	7	2	0	3	4	5	9	9	1	2	5	4	7	1	5	4	1	4	1	0	4	6	3	3	1	2

Table 6.3. Summary of the answers to the feedback questionnaire. In the rows there are the counts for the Likert levels: Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree. The table is color-coded for the themes used to generate the questionnaire, and the headings of the columns refer to the items in the questionnaire. The cells are shaded to according to the distributions of the answers to each question.

B18. I felt it was easy to discuss ideas and intentions with the group

Participants reported feeling a little more in control during the composition task (B10) than during the discussion (B9). This may be explained in two ways. First, the discussions saw rather equal contributions from all the participants, although in some cases one participant acted as a leader, proposing points for discussion and summarising decisions. In at least two sessions, one participant contributed less than the others, although with focused comments. One of these two participants reported a score of 2 in B9 "*because I don't know the technical terms of music*". However, individual analysis of these two cases revealed that both felt that their contributions were generally well-received (B15). Second, in the composition task, videos show that participants tended to behave in a way that would not impede other participants from using the DTMI, thus encouraging everybody to play their part. Feeling the possibility of taking control, and having the ability to give control up in favour of other participants, may explain why participants generally experienced a higher sense of being in control (B10) during the composition task – "*sometimes a little too much*" – than during the discussion (B9). Self-confidence played a role for some participants, in particular the same participant that did not "*know the technical terms of music*", did not feel in control "*at all, but because of my insecurity with the task*".

Perceived quality of the collaboration (discussion)

Items B12 to B14 were concerned with individual contributions to the collaboration, including all the activities from the initial discussion to the final composition task.

B12. I felt that I could contribute to the collaboration
B13. I felt comfortable contributing to the collaboration
B14. I felt that I was contributing a lot to the group work

Generally, participants reported that they felt quite able to contribute (B12) and that they felt comfortable in doing so (B13) commenting that the session was "*very relaxed*", that the "*lovely two participants helped*", and that it was "*very nice, no pressure*". Contributions to the discussions were fairly uniform from all participants: although some contributed more or less than others, all participants brought the discussion forward, to the extent of their abilities. In fact, the overall satisfaction with the discussion was quite high (B1, "*I am satisfied with the discussion*"). Participants' comments included "*very enjoyable*", "*the discussion progressed and new ideas emerged*", "*it was interesting comparing notes with other people*". However, one participant thought that the discussion was "*definitely too brief for that complex concept*", and one group "*lost focus a couple of times*". Generally, the discussion was considered useful, to various extents, in understanding similarity and contrast in music (B2, "*The discussion helped me understand similarity and contrast in music*"). Participants commented that they "*had much more ideas about it* [similarity and contrast]", "*loved learning from other participants*". However, some participants "*might need further discussion*": "*not really understand, but refine my previous conceptions*", "*understand is probably too strong, but at least it helped being more aware of it*".

Lastly, items B16 to B18 let participants report on the quality and ease of the group work.

- B16. I felt that the final piece of music reflects the way in which the group worked
- B17. I felt it was easy to communicate my ideas and intentions to the group
- B18. I felt it was easy to discuss ideas and intentions with the group

Nineteen participants thought that the final piece of music reflected the way in which the group worked (B16, "*it was collaborative*"), and that communicating and discussing their ideas and intentions was reasonably easy (B17), although one participant commented that their group seemed "*to have strong opinions on certain definitions*", explaining afterwards that this may have made the discussion a little difficult from time to time. This comment was acknowledged by the other two participants in the group.

Assessment of the storytelling exercise (musical outcome)

Questions B4 to B6 asked participants for their opinion on the final exercise.

B4. The final result is a nice piece of music
B5. The final result makes a good use of similarity and contrast
B6. The final result is original

When asked if they thought that the composed melody was a nice piece of music (B4), participants were distributed symmetrically between disagreeing and strongly agreeing (see table 6.3). The term "nice" was purposely vague in the hope to elicit comments: instead of "nice", the melody was regarded "*more of an example*", "*much work still needed*", although one participant "*would publish it*". Generally, "*the idea was nice, not sure the end result was*", "*I like it,* [...] *I'm not sure it's nice*". Rhythm and timbre constraints were felt by some as too restrictive – "*I feel really constrained in the possibility in terms of rhythms*" – and one felt that the premise was too sanitised – "*music needs emotion, not only similarities and contrasts*" – although learning about similarities and contrasts was the explicit purpose of the session.

When participants were asked if they thought that the melody was "original" (B6), 14 agreed or strongly agreed. Among the comments, one participant said that "*it is pretty generic*" and another one said that "*I think I saw a Disney movie about a bird flying*", suggesting that the story that the group invented was perhaps not very original. This, combined with the comments above, would suggest that imposing too many constraints on novices could adversely impact their ability to compose music that they can perceive as both original and pleasant. In reality, if we exclude particular edge cases, constraints of various kinds are universally present in music composition, regardless of whether a skilled composer is at work (Pearce et al., 2002), or a student is working through exercises (Russo et al., 1983). The reaction of the participants may be explained by the fact that they were not given an explanation of the constraints that they were going to work with, and therefore they may have seen them as arbitrary, and more like obstacles rather than an attempt at guiding their work.

Self-confidence and future attempts (personal outcome)

Questions A3 and B26 asked whether participants had composed original music in the past, and whether they thought they were likely to try again in the future.

A3. Have you ever composed original music?

B26. I will compose original music in the future

Only three beginners reported having composed original music "once or twice" previously, and ten beginners reported that they might try in the future – i.e., they did not "disagree" or "strongly disagree". In particular, some participants commented that self-confidence in their ability is crucial – "*I may try, but it will take some radical improvement (of my composing skills) to do so*". On the other hand, some acquired motivation to compose – "*this study would motivate me to study how to compose original music*". In reality, participants struggled to find reasons to compose original music in the future – "*maybe, but at the moment it is not in my purpose*", "*no idea, lullabies for grandchildren?*" – although one had clear goals: "*part of my course is about composition, so I will have to compose original music for my coursework*". All these statements are encouraging: the first two suggest acknowledgment of one's own limits, and perhaps the will to overcome them; the last three underline the need to have a reason to compose original music, suggesting the need for motivation when approaching a potentially time- and resource-intensive process such as the study of music composition.

Questions A3.1 and B25 inquired about the participants' confidence in their ability to compose original music.

A3.1. How confident are you in your ability to compose original music?

B25. I will compose original music in the future

Generally, pre-session confidence was rated low (A3.1, mode = 1), although, expectedly, the ratings of the non-beginners were more spread out than those of

	SD	D	N	A	SA
beginners	2	**6**	1	5	0
non-beginners	0	4	1	4	1
total	2	**10**	2	9	1

Table 6.4. Answers to statement B25.

B25 \ A3.1	1	2	3	4	5
SD + D	0.82	0.18	0.9	0	0
N	0.5	0.5	0	0	0
A + SA	0.1	0.4	0.2	0.2	0.1

Table 6.5. Proportions of pre-session confidence (A3.1) grouped by answers to B25. In the rows, the Strongly Disagree and Disagree levels were grouped, as were Agree and Strongly Agree.

the beginners (see table 6.2). The answers to statement B25 are shown in table 6.4.

Participants were quite polarised and balanced between agreeing and disagreeing with the statement – in all the three groupings, the most frequent answers were "agree" and "disagree" – therefore it is difficult to draw conclusions. Upon closer inspection, the 12 participants who disagreed, or strongly disagreed, with B25 were generally more likely to have reported lower confidence in A3.1 than the ten who agreed, or strongly agreed, with B25 (table 6.5). This may mean that participants who were initially not very confident, were still not very confident at the end of the session.

Four participants commented to B25 as follows:

- *"I would perhaps be able to compose something, but that would be miles apart of something aesthetically beautiful"*
- *"I haven't got enough knowledge to compose what I consider* proper *music – I'm working on that, though"*
- *"This group discussion can help me perhaps in the future to compose original music"*

- *"A little more than before, but it's a looong way".*

In light of all the above, one may speculate that taking part in the study did not have much of an impact on the self-confidence of the participants (figure 6.5). However, table 6.4 suggests that, for half of the participants, including those who were neutral, this might not have been the case.

Assessment of the DTMI (interface)

The following statements were to assess the experience that participants had working with the DTMI during the session.

B8. The tabletop interface was a good medium for the explanation and discussion of musical ideas
B19. The interface was frustrating
B20. The interface was confusing
B21. The interface supported the discussion and group work
B22. The interface gave me clear feedback on what was happening at all times
B23. The interface made it easy to communicate my ideas and intentions to the group
B24. The interface made it easy to discuss ideas and intentions with the group

The DTMI was considered a good medium for discussion (B8) by 12 participants, "*especially during the first step* [the discussion]", "*although constrained*" in what could and could not be done musically, and missing some desirable features. For example, one participant commented that "*it's better to have copy functions*" to avoid having to copy blocks manually. Overall, the DTMI was considered "not frustrating" by 16 participants (B19). Comments included:

- *sometimes… but otherwise ok*
- *there were not enough functions, all the notes are 1/4, the lack of whole notes or half notes limit our ability to convey emotions*
- *fun and a bit frustrating, I'd happily use it again.*

Twenty-three participants considered it "not confusing" (B20), commenting:

- *it was clear, sometimes quirky*
- *reasonably clear, just a few surprises*
- [not frustrating] *once the rules are known.*

This was not without caveats: for example, participants had difficulty pointing their fingers to exact locations on the screen. This could be consequence of the fact that the touch-sensitive glass panel was separated from the LCD panel by a few millimetres, creating a slight parallax misalignment between the point that the finger touched and the point where feedback was drawn. This in turn made hitting the play/stop button particularly frustrating – "*just to stop playing*" – and one participant remarked that this was limited to "*the technical parts that are out of your control: the quality of the touch screen did not seem great*". This suggests that larger controls might be a necessity with touch-screens of these dimensions, and in fact a related concern was previously addressed with the connection outlets.

The feedback that the DTMI provided was rated adequately clear (B22), and the interface made it relatively easy to communicate and discuss ideas with the group. Comments to B23 and B24 included the following.

- B23: *due to slowness, sometimes taking too much time to efficiently communicate*
- B24: *once entered, everything is quite smooth*
- B24: *in my opinion, for a real musician there are not enough options to completely communicate musical ideas*

This suggests that the DTMI adequately supported discussion and group work adequately, making it viable as a discussion mediator.

Returning participants

Ten of the twelve returning participants stated that they preferred this session compared to the previous one.

- *Difficult to say, though. Confronting ideas was very nice, less constraints than last time.*
- *More communications with the others; learn from the others; team work*
- *They were totally different experiences and I really enjoyed both of them. The second one though was much more challenging, which was a great thing as we had to exchange our ideas of similarity and contrast, and most of the time this was happening outside the context of music as none of us, as far as I understood, was a musician.*
- *Collaborating and working with people who really know about music, that have the correct vocabulary, understand the concepts under discussion (e.g. scale, melody, etc.).*
- *This time it was easier to take the decisions. Also, as I am not very creative in story telling, it helped me to create the story to tell.*
- *Because it was easier. You can share and mix your ideas with the group and feel more confident in the composition of the melody. If you have a doubt, you can share it with the group and go ahead easily.*
- *I liked the fact that this session was less structured and explored the advantages of, and dynamics of, group collaboration and team based learning. The focus felt more on independent composition and less on identifying elements of others'.*
- *I did like talking to more people, it felt more like a discussion than a lesson.*

On the other hand, the two returning participants that preferred Study 2 said:

- *I think I generally prefer working alone*
- *There were more opportunities to make music in the previous session.*

Arguably, the structure provided by Study 2 helped participants to progressively become familiar with the notions of similarity and contrast in melody, and how to use them to produce a sense of narrative. However, the widespread appreciation of the group discussion, and the ability to exchange ideas and to learn from different points of view confirms that tabletop interfaces are particularly well suited for group work, and that they facilitate sharing and discussing information.

Summary

Participants had a generally pleasant experience; they felt comfortable in discussing the topic, and able to undertake the storytelling composition challenge – although some doubted that the final result was "nice", nor that they would be able to compose "*proper*" music by themselves in the future without further study.

There were some minor incidents – for example, two groups started digressing and lost focus a couple of times – and some participants felt that the time that they were allocated for discussion was too brief, and did not allow them to explore the topic fully. However, the majority of participants felt that the discussion and activities helped them better understand, to some extent, the role of similarity and contrast in creating structure and narrative in music. More than 60% agreed or strongly agreed with B2 ("The discussion helped me understand similarity and contrast in music") and B3 ("The group work helped me understand how structure and narrative in music can be achieved through similarity and contrast"). Comments included:

- B2: *yes, loved learning from other participants*
- B2: *understand is probably too strong, but at least it helped being more aware of it*
- B2: *a bit better, but I might need further discussion*
- B3: *I have had much more ideas about it…*
- B3: *we thought about* [structure in music] *the other way around, how similarity/contrast can be achieved through structure.*

More than 90% felt at least neutral toward the two statements.

Based on the assessment provided by the participants in the post-session questionnaire, the DTMI was confirmed to be adequate as a mediator for discussing quite complex musical concepts. However, some comments subtly suggested that, although discussion with peers was nice and helpful, an intervention by a knowledgeable person – like a tutor – would have made the sessions more focused, improving learning.

6.5.3. Analysis of the discussions (SQs 3.1, 3.2, and 3.3)

In the following analysis, the group discussions are analysed looking for the criteria for similarity and contrast that participants identified, the styles of discussion leadership, and the ways in which the groups discussed melody around the DTMI.

Criteria for similarity and contrast

With half of the participants returning from the previous study on the same topic, and with half of the groups referencing what was discussed in their previous sessions, it was not very surprising that no new criteria for similarity and contrast emerged in this study. In two of the groups, a returning participant explicitly started the discussion by recalling what they discussed in the previous study, and this provided the group with a starting point.

> 1: *The last time we talked about similarity on chairs, so maybe we can start with the chairs that we have*
>
> 2: *Ok? So there's similarity and contrast both in shape, colour, and material, or you can judge by the comfort you have while sitting*
>
> 3: *So there's comfort, I never thought of that*
>
> 1: *Me neither. When I was in my first session I was thinking more of the materials and colours and shapes. So I think we should see the difference between our three chairs. I can see you have two chairs that are the same, 100% similarity, so how do you see that* [points] *chair, the differences…*
>
> 1: *I can't remember what I said the last time, I guess I said similarity is recurring after a state occurred on whatever you were looking at, and basically we're going to measure something, and that measure is the same across the experimental… but the way of measuring things can be different, it can be very precise or coarse, so it can take various forms.*
>
> 3: *The last time I said similarity is absolutely the same, both in function and form. About contrast, I think it should be 80-100% different!*

> *And also I talked about two things can be similar and contrasting, for example a different type of car have the same function but different appearance, like red colour and blue colour are contrasting in colour but they have the same function.*

In those groups that did not explicitly start in this way, the returning participants mentioned, throughout the discussion, observations and criteria that came up in their previous sessions. Regardless of when this happened, having at least one participant bringing up points for discussion helped in keeping the first part of the discussions focused and relatively short.

The fact that no essentially new criteria were identified may be explained in two ways. First, the criteria that were identified in Study 2 were mostly common, even obvious, criteria that can be used in everyday life, therefore it was likely that at least some of these would be discussed in Study 3. Study 2 provided a fairly representative set of common criteria for similarity and contrast. However, the criteria that were identified in Study 2 were by no means a complete universal discussion of similarity and contrast. This brings up a second possible explanation: by mentioning some of the aspects of similarity and contrast that they had discussed in Study 2, the returning participants may have primed the group, and possibly limited the breadth of the discussion.

Types of discussion leaders

In all the groups, a leader could be identified, although it was not always the same person that led both the general discussion and the musical discussion around the DTMI. In some cases, leaders were clearly identifiable at the beginning of the each discussion activity, as they were those posing questions, and summarising focus points. The three following examples, from different groups, begin with the current leader.

> 2: *So, can we assess contrast if there's no basis of similarity?*
>
> 1: *You can probably always find one, like you can say the concept* [inaudible] *and you go on and make a dimension in which you compare things that don't seem to…*

3: *Do we understand contrast as opposite to similar or not? For me, they are not*

1: *They could be similar and contrasting*

2: *But I think that's why the notion that there are aspects and dimensions of the characteristic that we're looking at, so contrast within a specific characteristics means difference but maybe sitting in a context of similarity in other characteristics.*

3: *Yeah, it is more difficult to me to discuss contrast, for example in the case of the chairs, the form is the same, the purpose is the same… so where is the contrast with chairs? This could be from a cultural perspective, the translation I make in my mind in Greek… so what is the contrast to a chair, is it another chair with less legs, or different colours? To me it would be totally opposite…*

1: *But then it's not a chair! It's a different thing. If you're making similarity and contrast on a particular object, that is softer, but if you're comparing two objects, definitely stronger! Table, it's a different purpose, different structure… you can't compare. That's why my idea is very soft*

3: *So for you both can be in this comparison*

1: *For me, how are you making the comparison? If same object, then it's soft, if another object, that's a different discussion. You can't compare a table with a chair.*

2: *Why can you not?*

1: *They are different objects for two different purposes*

2: *But you can sit on a table as well…*

3: *But that's not the purpose of the table, I guess.*

1: *Yes.*

2: *It depends…*

3: *It's like when you compare an apple with a banana…*

2: *They're both fruits*

3: *Yeah, but how can you compare the…*

1: *Ok. Dissimilar things can be things that can feel different*

3: *So, the obvious criteria would be shape, size, colour…*

1: *So, like, appearance, would we be able to consolidate those three into appearance?*

2: *I like appearance*

1: *If we discuss how those map onto* [music] *like size as length, breadth as scale…* [pause] *Function maybe a little? Like, is that a musical… music for enjoyment or a fire alarm? They are sounds for different purposes*

3: *Yeah*

2: *Totally*

1: *And the combination of instruments making a sound, versus a computer making a sound*

In other cases, instead, leaders were "elected" by the group based on how knowledgeable they were perceived to be – this was however not explicit, but rather shown by participants progressively and increasingly agreeing with the leader, and this model was rather fluid, as different leaders could emerge during the same discussion phase, depending on the points being discussed. Participant 2 in the following excerpt states an opinion that is discussed and agreed upon.

2: *I'd say all boomerangs are similar, because they come back and you can use them to hunt*

1: *Well, not all of them surely are for hunting… like the star ones, I don't think they were used for*

2: *Yeah, probably*

3: *So what do we say? Some boomerangs are more similar than others?*

1: *I guess…*

2: *You can say that not all of them are used for the same purpose, but they still come back if they don't hit anything, so that makes them all boomerangs*

1: *Yeah*

3: *Yeah… I suppose…*

In this case, participant 2 does not take the role explicitly but is instead recognised by the other participants. It can be hard to determine this from the transcript, and in fact it only becomes apparent when examining the body language of the participants. In the case above, participants 1 and 3 are seen to be more likely to turn to participant 2, rather than to each other, when speaking, as if they were prompting a response from participant 2.

The transition between the general discussion of similarity and contrast, and the same discussion in the context of melody, around the DTMI, was managed autonomously by five groups, whereas the researcher had to intervene in three cases where the discussion was lasting more than fifteen minutes, and the group was clearly digressing and losing momentum.

Styles of discussion around the DTMI

The second part of the discussion, the one on melodic similarity and contrast around the DTMI, was focussed on identifying similarity and contrast in melody. As in the general discussion, no essentially new criteria emerged compared to those found in Study 2.

Videos show that, in all cases, participants spent at least a few seconds playing around with the DTMI, trying to understand how it worked. In all but one case, returning participants explained to new participants how to use the interface. This did not happen in one case because the group was formed entirely by returning participants. After at most one minute of exploring the interface, the groups re-focussed on discussing the topic. Sometimes, one participant would explicitly prompt the group to start working.

> 2: *Shall we focus on similarities and contrast?*
>
> 1: *So, given these dimensions* [time and pitch], *you can have similar shapes, or rhythm wise you can have… similarity in that way*
>
> 2: *Shall we listen to it?* [plays] *A complete contrast would be… well, this is a contrast, because this part is kind of similar, but then it changes, the second matrix is kind of contrast*

In other cases, the participants worked independently for a while and then started discussing the examples that they produced. Some marked this transition explicitly – "*do you want to play and discuss them?*" – whereas others preferred to just voice their opinion

> 1: *One of the contrasts here is that it's constantly changing*
>
> 2: *Yes, but here instead… is this contrasting?*
>
> 1: *You're right, this is constantly changing, but for me it's not contrasting*
>
> 3: *Because it's uniformly changing, always going up and down. These have stuff in common, but I'm not sure what it is.*

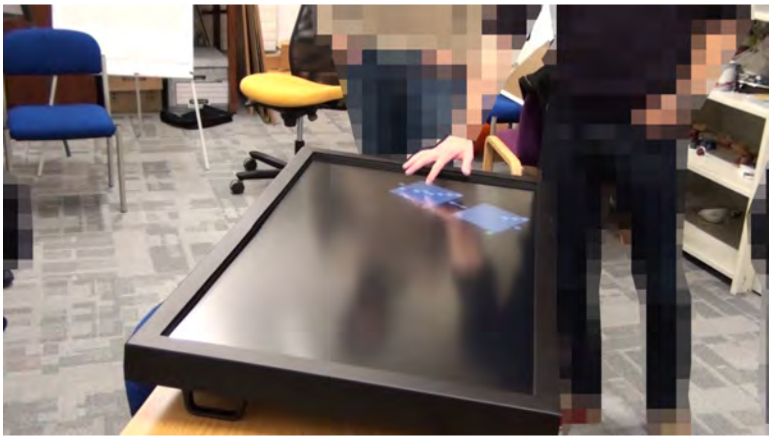
The above can be considered evidence of Mutual Awareness (MA), since in both cases there was a moment at which the participants acknowledged explicitly the others' work, and decided to begin discussing it.

Two groups hesitated on how to proceed in the discussion, thus a few options were suggested to them by the researcher. For example, it was suggested that they could each choose some criteria for similarity or contrast, exemplify them by composing a pair of melodies, and then propose the pair to the group for discussion. In fact, the six groups that did not hesitate, proceeded in similar ways, either by going around and producing one example each, which was then discussed by the group, or by producing one example – a pair of similar or contrasting melodies – and progressively modifying one of the two melodies to be either more similar or more contrasting with the other one used as a reference. In the latter case, discussion sometimes reached a dead end, thus a new pair of melodies was created, and the group resumed their discussion. The above can be considered evidence of Externalisation (Ex), in that the DTMI allowed the participants to create objects and discuss them through its interface. Furthermore, the way in which the participants progressively modified the examples produced by the others can be considered evidence of Mutual Modifiability (MM).

Turn-taking and continuous interaction Two styles of interaction and discussion were observed: *turn-taking*, and *continuous interaction*. In turn-taking, one participant at a time stepped closer to the table for the shortest amount of time necessary to create a new example, or to make changes to an existing one (MM), and then stepped back to discuss the objects on the table (Ex). The sequence shown in figure 6.2 shows a participant approaching and leaving the tabletop, while the other two stand back and wait.. In this way, participants ensured that they all could have a clear view of the DTMI's surface, and also provided the others with opportunities to step in and make changes, or propose new examples. Turn-taking was found to coincide with slow-paced discussions, in which participants preferred examining few options in-depth instead producing many different alternatives (Ex). The following is an extract of dialogue between participants in a group that adopted turn-taking: video evidence shows that all participants stood at a distance from the table, getting close to it one at a time in order to make their changes, as shown in sequence 6.2. The video also shows that the discussion was moderately-paced – this seemingly short extract lasts for about 30 seconds – possibly meaning that participants took their time to think their contributions through.

> 3: *The reason I find them similar is that because they follow the same structure*

(a)



(b)

(c)

Figure 6.2. A participant taking his turn.

Figure 6.3. Participants in *continuous interaction*

1: *The structure is the same, the pitch is higher*

3: *So do you think contrast or similar…?*

2: *That tends to be my position because you can't really say either, you can tell both*

In continuous interaction, either two or all three participants stood close to the table for longer periods of time, and worked together making frequent changes at a fast pace (MA, MM). Figure 6.3 shows an example of continuous interaction. In this way, pairs typically focussed on discussing details and variants of the block on screen, but this also meant that one participant was often excluded from discussing one particular example – although three-way discussions occasionally happened (Ex). The following is an extract of dialogue that occurred while two participants (1 and 2) were working on the same two blocks concurrently, while participant 3 observed and commented – the extract lasts for about 40 seconds, and a still is shown in figure 6.3.

2: *Oooh! So the meeting point comes slower*

1: [continues working, plays]

3: *Can you slow it down?*

1: [stops] *I don't think so?*

3: *So if you had fewer, would it make a longer time between steps?*

2: *Perceptually yes, instead of pressing one after the other, you would just press the odds, say, or...*

1: *If you, sorry?*

2: *So, instead of pressing each of the rows, or columns, you would do just the odds, or the evens, so just one yes, one no, yes, no...*

1: *Yes*

The turn-taking style was used by all the groups in the musical discussion phase, although two groups occasionally switched for brief moments to continuous interaction with two participants working concurrently. Although the continuous interaction style was primarily used in the composition task, two groups adopted it during the discussion, at a slower pace to make time for discussing and planning before acting. One group had one participant primarily working on the DTMI, while the other two contributed mostly with discussion and less by interacting directly with the DTMI.

Participants who contributed more or less to the discussion could be identified in all the groups. Videos show that, when participants operated in turns, every participant had generally more opportunities to take control of the DTMI than when they were operating in continuous interaction. This was because control of the DTMI was explicitly taken and relinquished by participants, thus clearly signalling when somebody else was allowed to step in (MA). The time spent discussing between subsequent interactions allowed considerable time for participants to step forward and take control of the DTMI. On the other hand, when working in continuous interaction, participants who initially tended to contribute less to the discussion were later seen engaging more frequently with the group and the DTMI. This can be seen in the videos, showing these participants standing closer to the table, paying attention to the others' actions, and contributing themselves (Ex).

6.5.4. Storytelling exercise

In the following analysis, the stories and melodies produced by the groups in the storytelling exercise are presented and analysed, to identify the strategies used in composing melodies that suggest narrative. The strategies outlined below come from the analysis of the melodies combined with the explanations that participants provided on the relation between the melodies and the stories. These strategies were identified using the explanations given by the participants. Entropy and cross-entropy were used to provide a way of evaluating the claims of the participants regarding the strategies that they used. Figure 6.4 summarises the occurrence of each strategy (coloured cells) in the storytelling exercises of each group.

1. The **use of similarity to mark related situations**.
   Groups 1, 2, 3, 4, and 8 identified distinct, yet related situations in their stories, and associated these with similar sections in their melodies. This highlights the role of similarity in creating structural coherence to different parts that are meant to be related.
2. The **use of different themes to mark different situations**.
   Groups 2, 4, 5, and 6 created stories by combining distinct sub-clauses, and used dissimilar sections to match these in their melodies, showing that difference, or lack of similarity, can also establish structure in melody by interleaving distinct dissimilar parts.
3. The **use of tension-resolution to convey a sense of narrative**.
   Groups 1, 3, 4, 6, 7, and 8 created stories that included moments of tensions and resolutions, and marked these moments with sequences of contrasting parts. This showed that contrast may play an essential role in creating the illusion of dramatic resolution (Laney et al., 2015).

The analysis of the group's works follows. Diagrams are provided at the end of this chapter, starting on page 223, and are referred throughout the rest of the analysis.

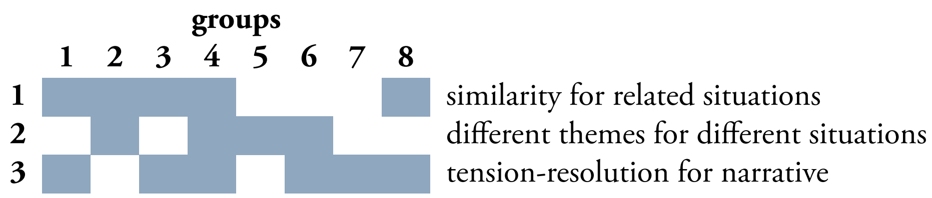


Figure 6.4. Occurrence of the strategies on each groups' work.

Group 1 page 223: "*a pirate tries to sell some loot, the deal goes wrong, he escapes, and goes back to plundering*" — The story begins with the pirate happily going up and down between potential buyers in blocks 1 to 4. In block 5, a sudden change of pace – signalled by a drop in entropy, from 2.2 to 0.9 bits – marks a change of scene, where the pirate is finally making a deal. However, in block 6, a similar, yet faster paced sequence of three notes marks a change in the mood of the scene, introducing the subsequent four blocks (7-10) in which the pirate rushes away, being chased, eventually making it back to his ship and setting sail for new adventures (block 11).

The change of pace between block 4 and block 5 – notably represented by a drop in Shannon entropy – marks a moment of tension in the story, when the mood changes because of the trouble arising for the pirate making the deal. Block 6 represents a step toward the next change of pace in which the pirate is being chased down – this is signalled by the average pitch, or "big picture contour", decreasing in blocks 5-7. The rhythmic figure in blocks 7 and 8 is very similar to the one used in blocks 1-4 – suggesting a similar lively action, also suggested by closer values of entropy to those of blocks 1-4 than to those of blocks 5 and 6. However, the difference between the highest and the lowest squares in the blocks is considerably smaller, and the notes are mostly in the lower end of the octave – following the previous change in the average pitch – suggesting that the pirate may be moving cautiously, hiding whenever he can. Blocks 9-10 represent a happy resolution of the troublesome part of the story, with contour rising in subsequent ramps, leading to a calmer, positive looking situation in block 11.

Group 2 page 224: "*birth and life and death of a person*" — The way in which group 2 mapped the story onto the melody was by describing different "ages" in single blocks: block 1 represented the moment of birth and infancy, characterised by "*high, happy notes, quite chaotic*", and overall quite lively ($H_1 = 2.2$), followed by a block representing youth – "*not so much going on*", where the contrast between blocks 1 and 2 can be seen by their rather high cross entropy $H_{1,2} = 6.4$ – and then by a block representing adulthood – "*get a job, live life, but progressing to old age*", $H_{2,3} = 5.8$. Old age and death come in blocks 4-6, where block 4 represents "*health degrading*", block 5 is "*a flat line… and then nothing*" in block 6. The group expressed their intention of telling a story using different phrases that suggest different moods: blocks 1 and 3 are characterised by lively up and down motion and wide intervals to suggest a state of chaos and busyness, and block 4 takes that business to a calmer point; blocks 2 and 5 represent the idea of very little going on – block 5 in fact partially represents death, appropriately having $H = 0$. However, participants made no effort to highlight specific details in this person's life, but rather focussed on describing the big picture.

Group 3 page 225: "*two strangers bump into each other, something happens – a big contrast! They bump spectacularly – and then they go in different directions*" — Blocks 1 and 2 describe the two characters as two voices, represented by alternating high and low notes, moving parallel in block 1, and then moving toward each other, until they meet on the same note at the end of block 2. One participant suggested this technique after mentioning something similar during the initial discussion – "*you can hear a melody, and when you slightly put the accent elsewhere you start hearing two melodies*", "*this may be interesting, there you can use a technique of… when you say this is X* [does] *and this is Y* [does], *you can actually hear them approaching… the technique I told before when you hear two distinct… and then you can make them approach*". The group identified a tense moment when the two voices meet on the same note, at the end of bock 2: the meeting of the two voices is followed by a short pause, at the beginning of block 3, marking uncertainty as to what is about to happen – "*something happens*", in the words of the participants. After the short silence, the two characters briefly move together, as a single voice, in the middle of block 3 – the participants indicated this movement as the small arc formed by the first three notes that appear in block 3. Then, according to the explanation given by the participants, one character moves first and goes in one direction – the melody moves downward in steps, and goes "*out of the picture*", presumably continuing downward at the beginning of block 4. Next, the other character goes in the opposite direction – the melody moves upward in skips, throughout the rest of block 4. Block 5 was described as a "*finale*", with no further comments.

According to the participants, there is a moment of tension at the end of block 2, when the two characters move towards each other and "*bump spectacularly*" after having moved in parallel through block 1. Musically, this is expressed by the two alternating melodies staying in their respective high and low ends of the range of notes during block 1, and instead occupying the middle range of notes in blocks 2. Consequently, the cross entropy between these two blocks is high – in fact, $H_{1,2} = 5.4$ is at the top of the range of cross entropies in this piece. This tense moment carries on for about the first half of block3, in which there is initially a moment of silence, followed by the three-notes arc described above, in which the two characters move together as one melodic line, and then the situation resolves in the second half of block 3, where one character exits the stage in one direction, and the other character exits the stage in the opposite direction, in block 4. The two different characters were rendered musically using different intervals in their respective movements. The first character to exit the stage does so in steps, whereas the second character does so in skips. Furthermore, the first character goes downwards, whereas the other goes upwards, that is, in the opposite direction, regarding to pitch. The participants considered these two blocks similar, because they represent analogous movement out of the scene, albeit in opposite directions. However, the cross entropy of blocks 3 and 4 is high again ($H_{3,4} = 4.0$), suggesting musical contrast, and in fact the two blocks share only three distinct notes, and differ in four notes, which explains the high cross entropy. In this case, cross entropy somewhat fails at predicting the similarity that the participants felt existed between these two blocks. The tension between these two ways of interpreting the same pairs of musical phrases – the interpretation of the composer, and the use of objective features – suggests that similarity and contrast in melody can be expressed in different ways, which need to be considered collectively in order to provide a rich understanding of them in relation to melody and narrative.

Group 4 page 226: "a new-born bird trying to fly out of the nest, then it drops, we're not sure if it makes it, and in the end we find it made it and it's flying" — It is interesting to observe the cross entropy matrix for this melody. Block 6 is where the fate of the baby bird becomes unknown, and is marked by a rather long silence, before the beginning of the resolution in block 7. In fact, block 6 scores quite high cross entropy against all the other blocks in the melody, making it quite a central moment in both the melody and the underlying narrative.

Blocks 1 to 3 represent the baby bird wanting to get out of the nest, and eventually jumping off in block 3. This is followed by block 4 describing the tentative, relatively calm flight of the bird (H_4 = 1.0) leading up to a tense moment in block 5 and 6, when the bird drops (H_5 = 2.0) and goes out of view in block 6 (H_6 = 1.5). Musically, block 6 is a rather busy moment, despite being mapped to a moment in which the observer is left in suspense with very little information, therefore the entropy of block 6 is rather higher than what one might expect, but still quite a low point surrounded by the local maxima in blocks 5 and 7 ($H_{6,7}$ = 5.1). The resolution of this tense moment begins in fact at the very end of block 6, after a pause signalling uncertainty regarding the fate of the bird. Block 7 describes then the bird flying back up in the sky, followed by three blocks (8-10) of confident flight, ending with the bird flying away in the distance (block 11) and finally disappearing. The analysis of the exercise reveals that group 4 was rather successful in understanding the role of similarity and contrast, and was quite effective in producing a mapping between the narrative and the melody that they composed.

Group 5 page 227: "*Dr Jekyll and Mr Hyde transforming into each other*" — The structure chosen by group 5 has three parts: a theme for Jekyll on the first two blocks, a theme for Hyde on the last two blocks, and in the four middle blocks "*the music changes slowly to represent the transition between the two states*". A closer look at each block's entropy reveals that the four "theme" blocks have distinct entropy values – Dr Jekyll has H_1 = 2.0, H_2 = 1.9, Mr Hyde has H_6 = H_7 = 1.5. Interestingly, cross entropies of blocks 1-2 and 7-8 (namely $H_{1,7}$, $H_{1,8}$, $H_{2,7}$, $H_{2,8}$, and their symmetrical entries in the matrix are among the highest, confirming the group's intention of using these to represent the two "contrasting" characters. Curiously, Dr Jekyll would seem to almost re-appear in block 4, as marked by high cross entropy with blocks 7-8 and low cross entropy with blocks 1-2.

On the other hand, the entropy of the "transition" blocks 3-6 rises throughout blocks 3-5, starting from a level comparable to those of blocks 1 and 2 – H_3 = 2.0, H_4 = 2.3, H_5 = 2.5 – and then falls – H_6 = 1.8 – towards the lower levels that are associated with blocks 7 and 8. This suggests that the transition from the friendly and sociable Dr Jekyll to the evil Mr Hyde is in fact a tense moment in itself. The high entropies of these blocks is an effect of the wide pitch intervals used to suggest a state of "*chaotic transition*", as explained by the participants. However, when the group explained their reasoning, they made no reference to any particular tense moment, but instead stated that they simply wanted to represent the "*chaotic transition*" between the two states of the character. This suggests that, similar to what we have seen for group 3, the intention of the participants, and the objective features, when taken in isolation, may not be able to describe in sufficient nuances the roles of similarity and contrast in melody in relation to narrative, but have instead to be considered collectively.

Notably, this was the melody that highlighted entropy as a more appropriate metric of liveliness in relation to the underlying narrative, as mentioned in section 6.4. Blocks 3 and 4 have a high standard deviation, creating a steep rise and fall in the otherwise fairly smooth curve. However, this feature of standard deviation had no meaning when compared with the story, whereas entropy produced a smooth curve throughout the entire melody. While it is true that the transition in the narrative was described by the participants as chaotic, it was not described as disruptively tense. Therefore, the smooth curve of the entropy can be seen as a better descriptor of the transition than the irregular curve produced by the standard deviation. While it is entirely possible that this is a coincidence, the nature of entropy – that is less directly and dramatically influenced than standard deviation by the amplitude of the values compared to their mean – may make it more appropriate as a measure of liveliness – although admittedly crude.

Group 6 page 228: "*one guy happily walking to the supermarket when he sees his romantic interest with whom the previous night he had a date that didn't go so well, so he wonders, but then the other guy waves and smiles, so everything is good*" — The structure is quite similar to the one adopted by group 4: there is an initial calm and safe situation – H_1 = 1.0, $H_{1,2}$ = 2.6, H_2 = 1.9, representing a relatively slow increase in activity – followed by an unexpected event that generates tension, in turn followed by an action that resolves the tension and provides a happy ending. The tension-resolution moment can be identified beginning at the end of block 2, carrying on through block 3, and making the first character nervous – represented by the high note in block 4. According to the group's explanation, the single note in block 5 represents the other character waving, to which the first character replies in the next block – $H_{5,6}$ = 0.8, representing two similar situations – thus resolving the tension, leading to the happy ending in block 7.

In this case, cross entropy partly fails to make useful predictions moving forward through the melody. For example, the tense moment in block 3 has a cross entropy of 1.7 with block 2. Conversely, block 2 has a cross entropy of 3.0 with block 3, and a similar case is observed with blocks 3 and 4, where the 4-3 direction shows higher cross entropy than the natural 3-4 direction. On the other hand, blocks 4, 5, and 6 show a rather high cross entropy with blocks 1 and 2: it is true that the former represent a somewhat tenser moment than that in the latter, but it is also true that the high cross entropy is due to the disjoint sets of notes used in the two groups of blocks. Nevertheless, we could argue that the choice of using low and high notes to signal opposite moods was intentional, based on the narrative.

Group 7 page 229: "*I went down to the grocery store, I couldn't find what I wanted, I went crazy, and then I went out of the store, and somebody's following me so I ran really fast until I got home and got on the door*" — While the leading participant proposed the story in the first person, all participants contributed equally to composing the melody. In this case, blocks 1 and 2 represent the initial scene where the main character is at the store and looks for something without finding it (block 1, mean = 2.83, H_1 = 1.9). At this point, block 2 marks the moment when the character "goes crazy" and exits the store, noticing that somebody may be following him or her. This results in the character fleeing in a rush through blocks 3 and 4, until finally he or she reaches home. The tense moment in block 2 is marked by averagely higher notes (mean = 4.67) compared to block 1 (mean = 2.83) and lower entropy (H_1 = 1.9, H_2 = 0.9) suggesting a state of high alert, and a relatively calm situation – i.e., the character noticed the potential stalker, but wants to avoid giving this information away. It is not however until block 3 that the action picks up considerable speed, as confirmed by $H_{2,3}$ = 6.0. The melody's block-wise contour – the mean of the blocks – keeps rising through blocks 2-4, falling back down in block 5, where the main character "*got home and got on the door*", marking the resolution moment.

Group 8 page 230: "*the wolf arrives at the three little pigs' houses, blows them down, but the third one doesn't fall, tries again, fails, so he sadly goes away*" — The melody begins by building up tension with blocks 1 to 3, describing the wolf stealthily approaching the houses. Blocks 4-5 and 6-7 represent the wolf blowing down the first two houses, and the occupying piglet fleeing to the next house. Blocks 8-10 represent the wolf trying to blow down the third house three times, and failing three times. In the following blocks 11-13, the wolf gives up, leaves, and disappears. Noteworthy is the attempt at increasing the tension across blocks 4-10 by raising the pitch, therefore the intensity, with which the wolf blows down the houses.

Interestingly enough, both entropy and cross entropy fail to produce any insight into the narrative, other than signalling some of the blocks that are similar due to their low cross entropy. However, the measure of similarity provided by cross entropy is not always nuanced enough. For example, blocks 4 and 6 have $H_{4,6}$ = 5.6, but a human listener would probably classify them as similar, despite the difference in pitch, and in fact, they do represent similar events in the narrative – the wolf blowing down a house.

6.6. Discussion

This study investigated how a group of people of mixed levels of musical experience – some novices, some musicians, some returning from Study 2 – worked together to explore the notions of similarity and contrast in melody, and the roles that these notions have in creating structure and suggesting a narrative in melody.

6.6.1. Performance in music composition

The main task of the study was inventing a story, or picking an existing one, and composing a melody that suggested that story in the opinion of the participants. As discussed in the analysis of the session activities, all the groups produced stories that were useful for the exercise. While the length and complexity of the stories varied, all the groups were successful in turning them into music, and in explaining what choices they made in mapping the stories onto the melodies that they composed.

Music composition strategies

As shown in figure 6.4, all the groups made use of either different musical themes for marking different situations, or moments of tension-resolution for conveying the corresponding moments in their stories. All the groups thought that their melodies conveyed some sense of narrative, but not all the groups used the same techniques. It is interesting to see that all the stories were created in ways that invited and involved the use of similarity and contrast, although in different ways. In particular, it is interesting to see the two different strategies adopted by the groups in relation to their stories. One strategy was the use of similarity and dissimilarity, used by group 2 to describe the slow degradation of related situation through the "*birth and life and death of a person*" (in motivic analysis notation, the melody composed by group 2 can be expressed as A, B, A', B', A", C), and by group 5 to describe the transition between "*Dr Jekyll and Mr Hyde transforming into each other*" (A, A', A", ..., B", B', B). The other strategy was the use of tension-resolution moments to mark the progression through the narrative, used for example by group 1 to describe the story of a pirate trying to sell some loot, and unexpectedly being chased (A, A', A, A', B, B', C, C', D, D', B"), and by group 4, that told the struggles of "*a new-born bird trying to fly out of the nest* [...]" (A, A', B, B', C, C', C", D, D, D, E, F).

Use of similarity and dissimilarity As discussed above, groups 2 and 5 worked with similarity and dissimilarity, rather than with similarity and contrast, to create a sense of continuously evolving narrative from start to finish. The distinction between dissimilarity and contrast is discussed in Study 2, section 5.5.4, and it was discussed by the participants in this study, therefore it was used as the basis for identifying this strategy. The stories proposed by groups 2 and 5 were about progressing between states. To represent this, the participants used different musical phrases to represent different parts of their stories. In the case of group 2, sections of the story that were intended to be similar in mood were marked by similar musical phrases; in the case of group 5, participants created a long, smooth transition between the two main states of their story.

Both groups convincingly explained how their melodies and stories were supposed to match, and their explanations provided evidence that they thought their work through, and that they deliberately chose how to use similarity and dissimilarity in their work. One could argue that neither group used contrast at all in their works, despite contrast being one of the contents of the session. However, the task that was given to the participants was to compose a melody with an underlying narrative, using what they discussed, which by no means implies that they had to use all of what they discussed. Overall, both groups can be considered successful in their performance.

Use of tension-resolution moments As discussed above, groups 1, 3, 4, 6, 7, and 8 worked with tension and resolution to convey a sense of narrative. In particular, groups 3, 4, and 6 chose to use silence to suggest tense moments, placing it between build-up and resolution moments. On the other hand, groups 1, 7, and 8 chose to create different moods to match different parts of their stories. In this second case, the tensions and resolutions were not made explicit by the melody, but rather implied by the contrast in moods, and shown in the mapping that the participants produced between their stories and melodies – interestingly enough, in all the three cases, the tension in mood is for scenes in which one of the characters is fleeing, possibly being chased. Both the use of silence, and of the contrast in moods, are valid techniques for expressing tension and resolution. Silence is an explicit musical feature, and it exists concretely in the melody, whereas mood can be implied by the melody, in more or less explicit ways, and exists primarily in the interpretation of the melody given by the listener.

All the groups provided more or less precise mappings between their stories and melodies, as discussed in the detailed analyses of each group's work. While the majority of the groups presented mappings that directly related whole melody blocks to clauses of their stories, some groups presented mappings that related parts of blocks to clauses of their stories – notably, groups 4 (block 5, comprising parts of two clauses) and group 7 (block 2, representing a combination of two states in the story).

Group work The groups worked in various ways. In some cases, leading participants appeared informally, although the various phases of the sessions did not always have the same leaders. Notably, work on the composition task was generally more egalitarian than during the discussions. In fact, during the initial discussion, one participant in each group was often found to contribute more than the others in terms of content and discussion points, although only occasionally by large margins. However, as the groups worked around the DTMI, a clear leader could not always be determined as easily as before. Instead, if a leading participant emerged at all, they acted more like a coordinator than a leader, proposing strategies for working around the DTMI and carrying on the discussion.

Participants' experience Based on their answers in the feedback questionnaire, and on the musical artefacts and discussions, it appears that the participants had a pleasant and meaningful experience. The overall goal was to take people who had previously never, or seldom, composed original music, and afford them not only the ability to do so, but also to learn concepts and techniques that are used in music composition at all levels. It is true that some participants had difficulties. According to them, this was mainly due to their inexperience with music, and lack of musical vocabulary, which led them to feel inadequate to participate in the discussion. However, it is also true that these were a minority, and, based on their questionnaires and video-recordings, they still had a positive experience, and contributed to the group work.

DTMI as a discussion mediator The DTMI proved adequate in supporting novices in a music composition task, confirming the same finding from Study 1 and Study 2. However, the focus of this study was on its adequacy as a discussion mediator: that is, a tool for supporting the discussion of similarity and contrast in melody by unobtrusively allowing participants to manipulate melody. . In this respect, based on the analysis of the video recordings, and on the feedback questionnaire, the DTMI fared well.

6.7. Conclusion

This study provided evidence to answer the questions stated at the beginning of the chapter.

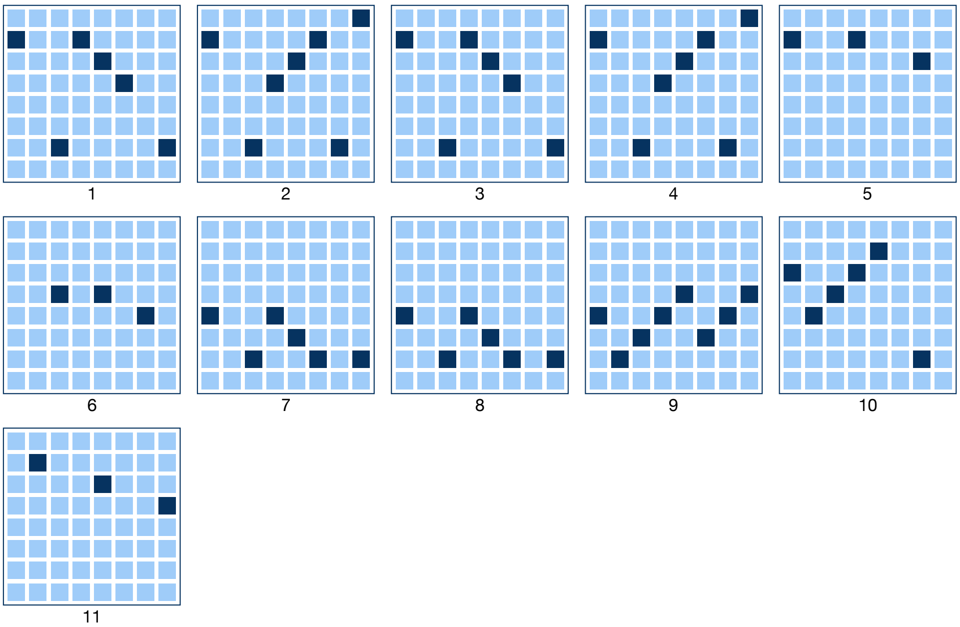
SQ 3.1. The participants developed ways of talking about similarity and contrast in melody. No new criteria of melodic similarity and contrast emerged compared to Study 2. The group discussion helped the participants to become aware of aspects of similarity and contrast that they had not previously thought about, or to refine their ideas about them.

SQ 3.2. All the eight groups could be considered successful in performing the storytelling exercise at the end of their sessions. The stories, the melodies, and how the participants explained the relations between the two provided evidence that they were able to use melodic similarity and contrast to compose music that suggested narrative.

SQ 3.3. The feedback questionnaire and the videos of the musical discussions and the storytelling exercises showed that the participants were able to use the DTMI to discuss musical examples in terms of similarity and contrast, and to compose music. This suggests that the DTMI was an adequate platform for supporting and mediating discussion. In particular, all the groups adopted a number of different strategies that provided useful insight on how to design educational activities around a DTMI.

SQ 3.4. The participants generally reported having enjoyed their sessions, although some found some of the activities more challenging than they expected. Generally, participants felt that they had learned more about the subject of the sessions, although some thought that they could have discussed the subject for longer, and in more detail, as they reported in the feedback questionnaire. Participants often commented that working in a group helped them become aware of aspects of similarity and contrast that they had not thought about, and that resulted in a rewarding experience for them. Furthermore, they were generally satisfied with their work on the storytelling exercise, which they explained convincingly.

Getting novices to compose music is a hard problem, and this study showed one way in which this problem can be tackled through the use of digital tabletop technology, and of appropriate software and conceptual tools.



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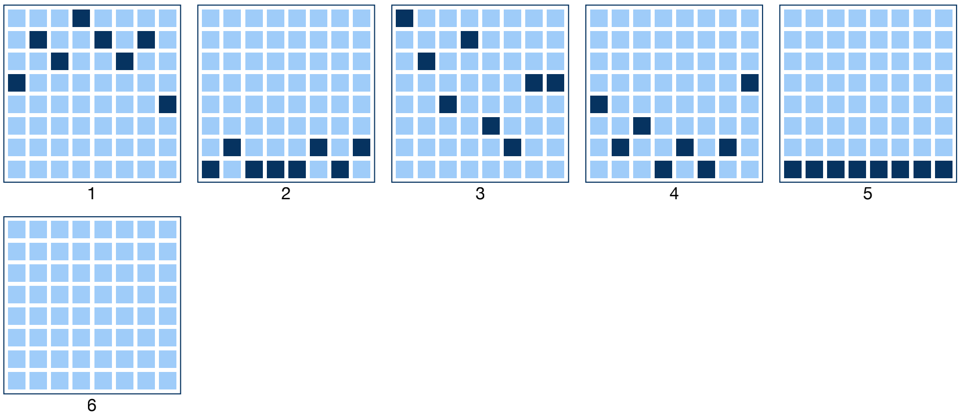
2.2	2	2.2	2.3	2.2	2.3	2.2	4.0	4.0	4.0	4.8	3.1	2.5
1.9	3	2.0	2.6	2.0	2.6	2.0	3.8	3.8	3.8	4.6	2.9	2.3
2.2	4	2.2	2.3	2.2	2.3	2.2	4.0	4.0	4.0	4.8	3.1	2.5
0.9	5	3.2	3.5	3.2	3.5	1.2	5.2	5.2	5.2	5.2	3.3	2.6
0.9	6	4.5	4.6	4.5	4.6	5.2	1.2	4.1	4.1	2.8	3.9	3.7
1.5	7	4.4	4.6	4.4	4.6	6.0	4.6	1.6	1.6	3.0	4.5	6.0
1.5	8	4.4	4.6	4.4	4.6	6.0	4.6	1.6	1.6	3.0	4.5	6.0
1.9	9	4.6	4.8	4.6	4.8	6.4	1.9	2.4	2.4	2.0	4.3	5.0
2.3	10	2.5	3.0	2.5	3.0	2.3	2.7	3.2	3.2	3.5	2.3	2.3
1.6	11	2.9	3.2	2.9	3.2	1.8	2.9	5.1	5.1	4.3	2.9	1.8

Group 1



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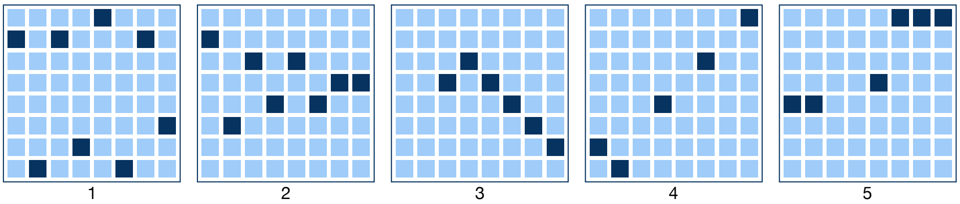
1.0	2	6.4	1.1	5.8	3.2	0.8	∞
2.8	3	2.9	5.1	2.8	3.7	6.3	∞
2.2	4	5.5	1.8	4.1	2.2	2.1	∞
0.0	5	6.4	2.5	6.4	4.9	0.1	∞
	6	∞	∞	∞	∞	∞	∞

Group 2



entropy	block	cross-entropy 1	2	3	4	5
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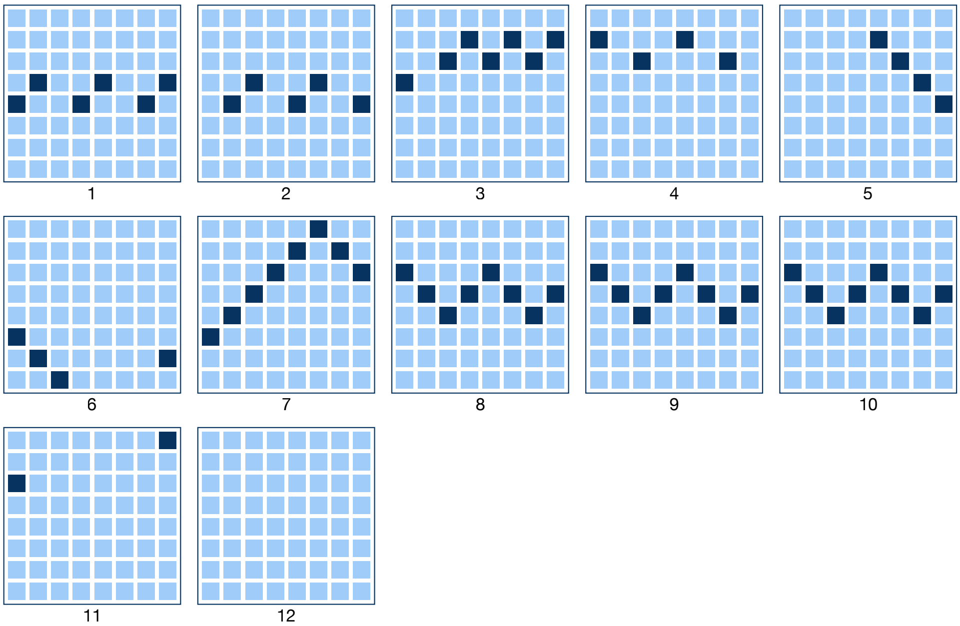
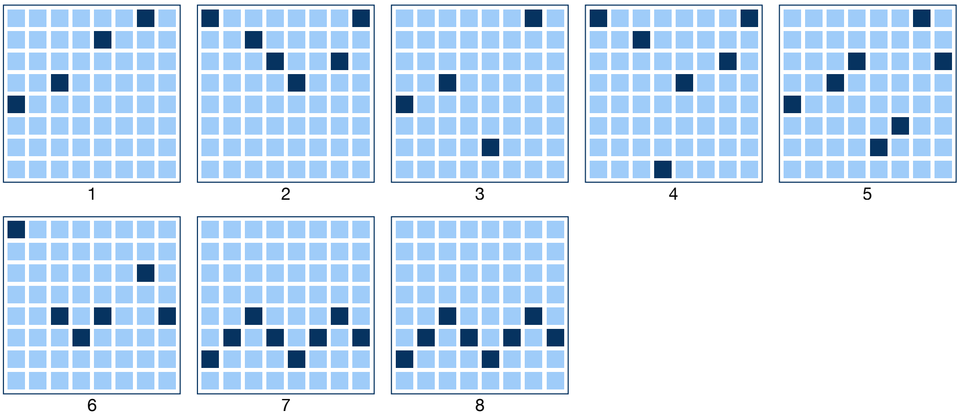
2.3	2	4.7	2.3	2.9	4.7	4.2
2.3	3	5.2	2.8	2.3	4.0	4.2
2.3	4	4.1	4.1	4.1	2.4	3.0
1.5	5	5.4	4.1	4.2	4.2	1.6

Group 3



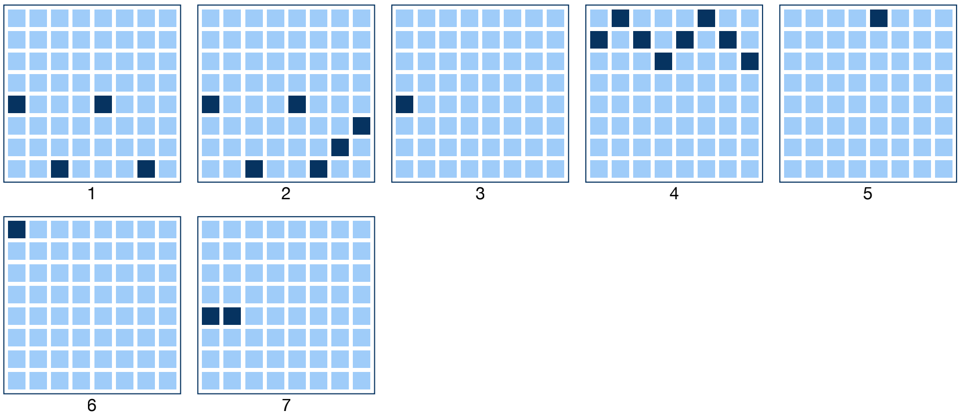
		cross-entropy											
entropy	block	1	2	3	4	5	6	7	8	9	10	11	12
1.0	1	1.1	1.1	5.3	6.0	3.6	6.0	4.8	2.4	2.4	2.4	6.0	∞
1.0	2	1.2	1.1	5.2	5.8	3.5	5.8	4.7	2.4	2.4	2.4	5.8	∞
1.4	3	4.6	4.9	1.6	1.3	2.9	6.2	3.4	3.3	3.3	3.3	3.8	∞
1.0	4	5.5	5.5	1.8	1.2	3.4	5.5	3.4	4.4	4.4	4.4	3.4	∞
2.0	5	2.1	2.1	2.1	2.1	2.1	5.5	3.0	2.1	2.1	2.1	3.8	∞
1.5	6	5.5	5.5	5.5	5.5	5.5	1.7	5.1	5.5	5.5	5.5	5.5	∞
2.5	7	3.0	3.0	2.2	2.0	2.5	5.5	2.5	2.8	2.8	2.8	2.5	∞
1.5	8	1.6	1.7	3.8	4.3	2.9	6.4	4.1	1.6	1.6	1.6	4.3	∞
1.5	9	1.6	1.7	3.8	4.3	2.9	6.4	4.1	1.6	1.6	1.6	4.3	∞
1.5	10	1.6	1.7	3.8	4.3	2.9	6.4	4.1	1.6	1.6	1.6	4.3	∞
1.0	11	4.7	4.7	3.3	3.0	3.9	4.7	3.5	3.9	3.9	3.9	1.4	∞
	12	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞

Group 4



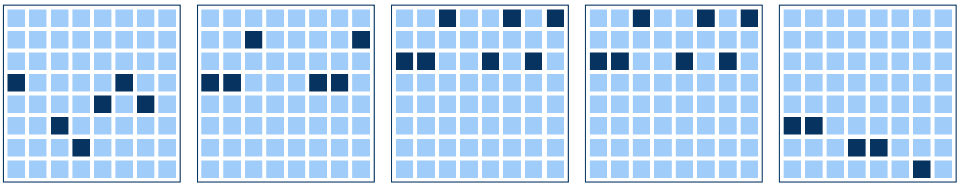
entropy	block	cross-entropy 1	2	3	4	5	6	7	8
2.0	1	2.1	3.2	3.0	3.2	4.0	3.2	4.6	4.6
1.9	2	3.3	2.0	4.1	2.7	3.7	4.6	6.0	6.0
2.0	3	3.0	3.8	2.1	3.8	3.6	3.2	3.8	3.8
2.3	4	3.2	2.3	4.1	2.3	3.9	4.7	6.0	6.0
2.5	5	3.7	3.1	2.9	3.8	2.6	2.7	2.9	2.9
1.8	6	3.9	3.8	3.9	4.3	3.4	1.9	3.1	3.1
1.5	7	5.3	6.4	4.3	6.4	4.4	3.4	1.6	1.6
1.5	8	5.3	6.4	4.3	6.4	4.4	3.4	1.6	1.6

Group 5



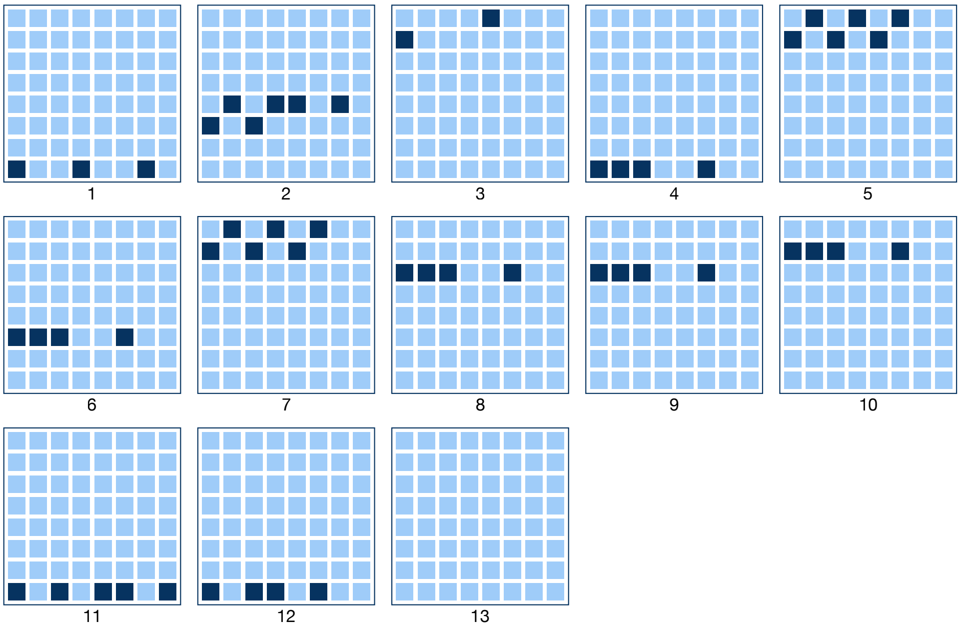
entropy	block	cross-entropy 1	2	3	4	5	6	7
1.0	1	1.2	2.6	1.2	5.5	5.5	5.5	1.2
1.9	2	1.7	2.0	1.7	6.0	6.0	6.0	1.7
0.0	3	2.4	3.0	0.8	4.1	4.1	4.1	0.8
1.5	4	6.4	6.4	6.4	1.6	2.1	2.1	6.4
0.0	5	4.1	4.1	4.1	3.3	0.8	0.8	4.1
0.0	6	4.1	4.1	4.1	3.3	0.8	0.8	4.1
0.0	7	2.6	3.3	0.4	4.8	4.8	4.8	0.4

Group 6



entropy	block	cross-entropy 1	2	3	4	5
1.9	1	2.0	3.1	6.0	6.0	3.3
0.9	2	4.3	1.1	6.0	6.0	6.0
1.0	3	6.3	6.3	1.1	1.1	6.3
1.0	4	6.3	6.3	1.1	1.1	6.3
1.5	5	4.3	5.8	5.8	5.8	1.7

Group 7



cross-entropy

entropy	block	1	2	3	4	5	6	7	8	9	10	11	12	13
0.0	1	0.3	5.2	5.2	0.3	5.2	5.2	5.2	5.2	5.2	5.2	0.3	0.3	∞
0.9	2	6.0	1.1	6.0	6.0	6.0	1.7	6.0	6.0	6.0	6.0	6.0	6.0	∞
1.0	3	4.7	4.7	1.4	4.7	1.4	4.7	1.4	4.7	4.7	1.4	4.7	4.7	∞
0.0	4	0.2	5.6	5.6	0.2	5.6	5.6	5.6	5.6	5.6	5.6	0.2	0.2	∞
1.0	5	6.0	6.0	1.1	6.0	1.1	6.0	1.1	6.0	6.0	1.1	6.0	6.0	∞
0.0	6	5.6	3.8	5.6	5.6	5.6	0.2	5.6	5.6	5.6	5.6	5.6	5.6	∞
1.0	7	6.0	6.0	1.1	6.0	1.1	6.0	1.1	6.0	6.0	1.1	6.0	6.0	∞
0.0	8	5.6	5.6	5.6	5.6	5.6	5.6	5.6	0.2	0.2	5.6	5.6	5.6	∞
0.0	9	5.6	5.6	5.6	5.6	5.6	5.6	5.6	0.2	0.2	5.6	5.6	5.6	∞
0.0	10	5.6	5.6	2.9	5.6	2.9	5.6	2.9	5.6	5.6	0.2	5.6	5.6	∞
0.0	11	0.2	5.8	5.8	0.2	5.8	5.8	5.8	5.8	5.8	5.8	0.2	0.2	∞
0.0	12	0.2	5.6	5.6	0.2	5.6	5.6	5.6	5.6	5.6	5.6	0.2	0.2	∞
	13	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞

Group 8

7 Conclusions

Music is still complicated. It is hard to argue that just introducing more and more technology into music education can make Western music easy. This should not stop us from trying to make learning easier for people who are willing to learn, regardless of whether they want to become the next big star, or just enjoy what is arguably one of the most ancient and widespread forms of art in human history and prehistory. In this respect, the three studies that were presented in this thesis were successful: they demonstrated that it is possible to design a piece of technology that can be used by both musically experienced and inexperienced people, in order to create music in a way that is graspable for the novice, yet expressive for the expert, so that the two can discuss it in ways that both consider meaningful.

7.1. Research question revisited

This thesis aimed at answering the following research question:

> How can we design a Digital Tabletop Musical Instrument that can support its users in discussing musical concepts, and in using such concepts to compose music?

In particular, a number of sub-questions were addressed in each study, and can be summarised as follows:

1. How do the users learn, discuss, and use the proposed musical concepts to work with melody?

2. Does the DTMI provide adequate support for its users to learn, discuss, and use the proposed musical concepts to work with melody?
3. Do the participants have an enjoyable experience that they consider meaningful and motivating?

The key findings are summarised in the three empirical studies:

Study 1: A study of melodic contour (Chapter 4)
Study 2: A study of similarity and contrast (Chapter 5)
Study 3: A group study of similarity and contrast (Chapter 6)

The following is a summary of the findings from the three studies for each of the questions stated above.

7.1.1. How do the users learn, discuss, and use the proposed musical concepts to work with melody?

- Study 1 provided evidence suggesting that most of the participants developed an intuitive understanding of melodic contour during the course of their session (§ 4.5.4). It also provided evidence that, when participants were explicitly tutored about melodic contour, they used the contour vocabulary more often and confidently than those who were not tutored. Lastly, the study provided evidence of different strategies that the participants employed for composing music using a painting as an extra-musical reference (§ 4.5.4).
- Study 2 provided evidence that the participants developed ways of thinking about melodic similarity and contrast (§ 5.5.4). Several criteria for melodic similarity, difference, and contrast were identified by the participants (§ 5.5.4). Furthermore, the study provided evidence that the majority of the participants successfully used melodic similarity and contrast to compose and describe a melody to suggest the story that they had chosen to represent (§ 5.5.5).
- Study 3 provided evidence that the groups of participants developed ways of thinking about melodic similarity and contrast (§ 6.5.3), although no

new criteria were identified compared beyond those identified into Study 2. Furthermore, the study provided evidence that all the groups were successful in using melodic similarity and contrast to compose a melody that conveyed the story that they had chosen to represent (§ 6.5.4).

7.1.2. Does the DTMI provide adequate support for its users to learn, discuss, and use the proposed musical concepts to work with melody?

- Study 1 provided evidence that the representation of melodic contour offered by the DTMI was expressive enough to communicate the relation between musical and visual shapes (§ 4.5.4). Furthermore, the DTMI did not pose significant usability issues to the participants, though some minor issues were identified, and addressed afterward (§ 4.5.3).
- Study 2 provided evidence that all the participants were able to compose and discuss melody using the DTMI (§§ 5.5.3 and 5.5.4). Further minor usability issues were identified and addressed promptly (§ 5.5.3).
- Study 3 provided evidence that the DTMI was adequate to mediate the groups' discussions of similarity and contrast (§ 6.5.2). Moreover, several strategies that the participants adopted for discussing and composing using the DTMI emerged, and provided further evidence that the DTMI adequately supported novices and experts in their collaborative work (§§ 6.5.3 and 6.5.3).

7.1.3. Do the participants have an enjoyable experience that they consider meaningful and motivating?

- Study 1 provided evidence suggesting that nearly all the participants had an enjoyable experience during their session, and some perceived the tasks as challenging. Furthermore, evidence suggests that the exercises were motivating for some users to engage again in music making (§ 4.4.2). Lastly, the DTMI posed some minor usability challenges that possibly affected the experience (§ 4.5.3).

- Study 2 provided evidence that the participants had a generally enjoyable experience, although some had to skip parts of their sessions, due to time constraints and the sessions running for too long (§ 5.4.3).
- Study 3 provided evidence that the groups had an enjoyable and meaningful experience (§ 6.5.2). In particular, participants felt that their discussion with a group, including people that they perceived as experts, helped them to think about aspects of similarity and contrast that they may not have thought about otherwise (§§ 6.5.2 and 6.5.2). Although generally the participants were satisfied with their work, evidence to suggest that their confidence in their ability to compose music was inconclusive (§ 6.5.2).

7.2. Theoretical, methodological, and practical implications

7.2.1. Theoretical implications

- Dillenbourg et al. (2011) argue that DTIs in general are "*neither good nor bad for learning*", but that they can be relevant to learning, and propose that more rigorous research is necessary. This thesis aimed to be a first step towards a systematic approach to understanding the role of DTMIs as tools for supporting music education. The results show that the combination of an appropriately designed DTMI and activities provided an engaging and educational experience for beginners and non-beginners (§§ 4.5, 5.5, and 6.5). In particular, Study 3 showed that a relatively flexible and expressive interface allowed beginners and non-beginners to collaborate, learn from each other, and compose music together in a way that both sides considered meaningful and enjoyable (§ 6.5).
- Similarity and contrast in music can be used to establish structure and suggest narrative (Laney et al., 2015). The existence of narrative in music is a highly controversial and subjective aspect of music, and yet something that is often exploited by composers. Composing music that suggests a narrative is not trivial, especially for people with very little musical experience. Studies 2 and 3 provided evidence that many participants

were able to grasp the role of melodic similarity and contrast in suggesting narrative, and to use them to compose and describe melody in terms of narrative. The studies also provided evidence that the DTMI provided an intuitively usable interface for beginners to compose and discuss music, with a tutor (§§ 5.5.4 and 5.5.5) as well as within a group of people of mixed levels of musical experience (§§ 6.5.2, 6.5.2, and 6.5.4).

- Laney et al. (2015) proposed cross-entropy as a measure of musical contrast. In Study 3, cross-entropy was used to identify moments of narrative contrast in a melody. Although the results suggest that cross-entropy was mostly successful in describing, and predicting, narrative contrast, further research is necessary. Study 3 also proposed the use of information entropy (Shannon entropy) as a measure of "liveliness" and "idleness" in melody, and as a way to describe the overall structure of the melodies. As discussed in section 6.5.4, group 5 in particular, entropy may be a useful descriptor for melodic structure, but further research is necessary. Counterexamples were found for which both entropy and cross-entropy did not work in the same way as they did for the majority of the cases. This may have been due to the relatively small number of cases (22 total between Study 2 and Study 3), thus it is possible that, with a larger data set, explanations for this failure may emerge.
- A variety of approaches have been proposed for computer-aided education (Dillenbourg et al., 2011) but not all have been successful in providing an engaging and effective experience (Malone, 1982). Truman (2008) proposed a WIMP-based approach to music education, showing how the design of the software and the educational activities can have an impact on the educational and engagement outcome. This thesis proposed the use of extra-musical materials to motivate a music composition exercise. The results suggest that this helped beginners and non-beginners to discuss potentially unfamiliar concepts by referring to them in a familiar context (§§ 4.5, 5.5, and 6.5).

7.2.2. Methodological implications

- Xambó (2015) studied tabletop interaction using ethnographies, interviews, questionnaires, and video recordings. This thesis sought to consolidate the methodology and apply it to the analysis of user interaction, and group interaction, with a DTMI used as a music education support tool. In addition, this thesis applied thematic analysis to the artefacts produced by the participants, in order to assess the learning outcome of the sessions (§§ 4.5.4, 5.5.4, 5.5.5, 6.5.3, and 6.5.4). The methodology was successful in producing a rich data set that made it possible to analyse (i) how the participants interacted with a digital learning tool, (ii) how the tool supported the participants in learning about musical concepts, and (iii) how the participants engaged with, and acquired, the musical concepts.

7.2.3. Practical outcome

- A piece of software for composing melody in touch-screen settings was developed (§ 3.4), assessed for usability (§ 4.5.3), and tested in a music education setting in studies 1 to 3.
- A number of key issues that should be considered for the design of individual and group DTMI-supported music educational activities were identified. In particular, the role of tutoring (§§ 4.6) and 5.6.1), and the role and dynamics of group discussion (§ 6.5.3) were examined in relation to the acquisition of the musical concepts.

7.3. Lessons learned

The studies presented in this thesis had two implicit goals for participants: to see that they could make music despite thinking otherwise, and to learn particular musical concepts and use them to make music. The participants produced good work, and this included not just music, but also, and most importantly, the discussions, thought processes, and interactions that happened during their sessions. In nearly all the cases, the participants came out of the studies knowing that making music was not a specialised activity from which they were excluded, that it is instead something that they can do, even if not in an expert way, given the right tools and motivation. Different people expressed this differently, depending on their level of musical experience. The participants who had some music-making experience were generally satisfied with their work, and those with less experience, if any at all, were happy to see that they could make something at all. With very few exceptions, the participants appreciated the constraints that the interface provided, and responded well to the constraints of the tasks. In fact, such constraints were critical in presenting a simple, streamlined, and easy to learn interface and activity, which allowed people to focus on the music, and to learn the musical concepts that were presented to them.

7.3.1. Actionable insights

Each of the studies brought to light a number of insights into the design of music educational software and technology-supported educational activities. However, with careful consideration, such insights may be applied to other disciplines than music.

The first problem faced during the study design phases was to figure out what were the key aspects of the particular musical concept under consideration, and how to talk about them with the participants. The approach chosen in this thesis was to survey the literature relevant to the specific concepts, and base design decisions on it. In a real-world educational setting, this work would be performed by educators who, using their own domain knowledge alongside the existing literature, can provide rich insights into specific concepts, and into the best ways of presenting and discussing them with students.

The second problem was to decide what type of activities would be useful to introduce the participants to potentially unfamiliar concepts. The preceding survey of the literature was useful for study 1, in the sense that it identified contour as a visual metaphor, therefore using a visual reference was a relatively obvious decision. On the other hand, the literature on similarity and contrast very rarely mentions narrative, but is focussed more on the notions of structure, and musical form. However, contrast is often used to create tension and resolution between parts. Thus narrative, expressed in terms of similarity and contrast, was an interesting topic for participants to explore.

The third problem, or set of problems, was specifically related to the technology. Broadly speaking, there is limited infrastructure to support the development of tabletop applications. For example, 2D gesture recognition is something that is very well developed in smartphones and tablets. However, not many solutions exist for the desktop, which is typically the platform used to develop a tabletop application. In fact, the few solutions that exist are usually proprietary, overly complex, not cross-platform, or tied to specific libraries, which further limits the choices for the developers.

Accommodating imprecise and informal interactions was another problem that surfaced throughout the three studies. For example, participants tried to connect blocks using imprecise gestures that often missed the connection outlets. This was iteratively addressed by increasing the size of the outlets, resulting in an overall better experience for the users. An example of an informal, or unforeseen, interaction was given by the (few) participants who wanted to use polyphony. Although this was not allowed in the context of the studies, the software was capable of handling it, therefore avoiding interruptions that might have lead to loss of focus and frustration.

In summary, the problems above are representative of typical situations encountered during the development of similar technologies and activities. While this thesis did not intend to investigate these issues in depth, it did nonetheless provide insights into the process of solving them.

7.4. Future work

Musical tabletops are a promising platform for music education, but research in the area is still in its infancy. This thesis aimed at demonstrating that the educational use of the technology is possible with respect to music, and the literature examined in section 2.1 suggests that digital tabletops can have a significant role in education in general.

7.4.1. Shared vs private use

This thesis focussed on tabletops, which are typically bulky. This means that interactions can only take place in fixed settings. Furthermore, they can have significant purchase and maintenance costs. These factors combined can make tabletops impractical for private use. For example, when a student wants to practise privately, and join a group session later. The literature on tabletops situated in public spaces is well established, and studies exist in which tabletop activities are performed concurrently by multiple groups, and the results are shared synchronously or asynchronously (Kreitmayer, 2015). Examples of shared vs private activities also exist in musical contexts, in the form of audience participation among others – for example, in “Deep Field” (Whitacre, 2015), the audience is part of the performance through using a special tablet application that plays an audio part of the score, whereas Hödl et al. (2012) developed a smartphone application for the audience to control the stereo panorama of a performance. Further research could focus on affordances for separating and integrating group and individual educational activities, in both classroom-type and public space settings: for example, using personal tablets for individual work, and a shared tabletop for collaborative work.

7.4.2. Public settings

Music education should not be limited to academic settings, although educational goals may be different from academic ones. In chapter 2, the educational relevance of TUIs, and of DTIs in particular, was discussed. Many of the systems reviewed, and many of those that are being continually developed and deployed, are designed with casual interactions by strangers in mind. Further research can focus on new forms of music education in public settings, considering the principles of flexibility and concreteness discussed in section 2.2, and applying them to create immersive experiences for large audiences.

7.4.3. Longitudinal study of students' performances

Studies 2 and 3 covered the same musical concepts, first with individual participants, and then with groups including new and returning participants. However, the two studies were conducted months apart, and the results seem to suggest that some of the effects of Study 2 on the returning participants had faded over time. On the other hand, the results also showed that the returning participants had retained memories of what they had discussed in Study 2, and this often helped the groups to discuss in a focussed way. Further research can investigate whether and how integrating tabletops into existing music education settings can have an effect on the students' performances.

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A Methodology materials

A.1. Tabletop hardware

The multi-touch screen shown on 256 resting flat on a table was used throughout the studies presented in this thesis. Audio was played through a pair of Roland CM-30 Cube Monitor speakers. Volume was set at a comfortable level, and adjusted to the preference of each individual or group of participants if requested by them.

E-VOLUCE 46” Multi-touch monitor

Roland CM-30 Cube Monitors

A.2. Pilot study

The study was approved by the OU HREC with reference number HREC/2012/1318/Franceschini/1.

The following pages present:

- Consent form
- Demographics questionnaire
- Feedback questionnaire.

Consent Form for **Collaborative Composition on Multi-Touch Surfaces Experiment**

The aim of this experiment is to collect, from each participant, the interactions with a tangible musical tabletop interface. Video footage will be taken during the experiment and used for further analysis. A small amount of additional information is also requested: musical experience, general comments.

The data will be made anonymous before it is made publicly available. All data are treated as confidential, and in compliance with the Data Protection and Freedom of Information Acts.

The experiment is estimated to take approximately 30 minutes.

You have the opportunity to withdraw from the experiment at any time with no adverse consequence.

You have the opportunity to have any supplied data destroyed on request, up to the point of anonymisation.

Still images and/or video footage taken during the experiment can be used in publications and presentations, with prior consent of the participant if the person is recognizable.

There are no risks associated with this experiment.

The results of the experiment will be used in my PhD thesis and in future publications. If you wish, I will be happy to inform you of any such publication when it occurs.

If you have any concerns or difficulties you may contact:

Andrea Franceschini (Main researcher)	andrea.franceschini@open.ac.uk	
Robin Laney (Supervisor)	r.c.laney@open.ac.uk	01908 654 342

This project has been approved by the OU's Human Research Ethics Committee.

I, ____ (print name) confirm that I have understood the above information and that I consent to participate in this experiment.

Signed: ________________________________ Date: ____________

Please answer the following questions about your **musical experience**.

1) Have you studied music?

   ☐ I have never studied music formally nor informally

   ☐ I received informal music education or I am self-taught

   ☐ I received formal music education

   - If you have, for how long? ________ years

2) Do you play a musical instrument?

   ☐ I play no musical instrument

   ☐ I play one musical instrument

   ☐ I play more than one musical instrument

   - If you do, how would you rate your skills from minimum 1 to maximum 5? ________ (considering your best instrument)

3) **(optional)** If you have studied music and/or played a musical instrument, at what age did you start? ________

4) Have you ever composed original music?

   ☐ I have never composed original music

   ☐ I have composed original music once or twice

   ☐ I have composed original music more than a few times

   - How confident are you in your ability to compose original music? (1-5) ________

Please answer the following questions about your **experience in this study**.

1) Rate the following statements depending on whether you strongly disagree (1) or strongly agree (5)

	1	2	3	4	5
☐ I felt we operated as a team	☐	☐	☐	☐	☐
☐ I felt part of a collaborative process	☐	☐	☐	☐	☐
☐ I felt that accomplishing the task was difficult	☐	☐	☐	☐	☐
☐ I enjoyed composing a piece of music	☐	☐	☐	☐	☐
☐ I concentrated intensely on the task	☐	☐	☐	☐	☐

2) How confident are you **now** in your ability to compose original music? (1: not at all, 5: a lot)

1	2	3	4	5
☐	☐	☐	☐	☐

3) How much would you consider trying to compose original music in the future?

1	2	3	4	5
☐	☐	☐	☐	☐

A.3. Application logs for the DTMI used in studies 1-3

The following is an example of the information contained in the application logs produced by the application used in studies 1-3.

```
                      type of gesture...                        ... corresponding action triggered
[1418748776004] TheApp::gestureProcessor LongTapGesture -- new MeasureWidget (x:1611.21 y:610.071 id:2)
[1418748780071] MeasureWidget::tap -- id: 1
[1418748780072] MeasureWidget::toggle id:1 -- pair: (1, 7) -- on  participant turned on a note on a block
[1418748780072] TheApp::gestureProcessor MusicStrokeGesture (points:[(0.783783,0.941956)(0.783783,0.941956)
                (0.783783,0.941956)(0.783783,0.941956)(0.783783,0.941956)(0.783783,0.941956)])

      ...

[1418749262813] MeasureWidget::play -- id: 1          participant drew a continuous stroke across a block
[1418749262813] MeasureWidget::tap -- id: 1 -- play   many notes are simultaneously toggled as a result
[1418749262814] TheApp::gestureProcessor MusicStrokeGesture (points:[(0.679138,0.817535)(0.679138,0.817535)
                (0.679138,0.817535)(0.679138,0.817535)(0.679138,0.817535)(0.679138,0.817535)(0.679138,0.817535)
                (0.679138,0.817535)(0.679138,0.817535)(0.679138,0.817535)(0.679138,0.817535)(0.679138,0.817535)
                (0.679138,0.817535)])
[1418749264812] MeasureWidget::play -- id: 2
[1418749264812] MeasureWidget::finishedPlaying -- id: 1
[1418749266829] MeasureWidget::play -- id: 1
[1418749266829] MeasureWidget::finishedPlaying -- id: 2

      ...

[1418751047867] Milestone free
[1418751047867] Sequence -- [59,0,50,59,57,55,0,50][59,0,50,55,57,59,50,60][59,0,50,59,57,55,0,50]
                [59,0,50,55,57,59,50,60][59,0,0,59,0,0,57,0][0,0,55,0,55,0,53,0][53,0,50,53,52,50,0,50]
                [53,0,50,53,52,50,0,50][53,50,52,53,55,52,53,55][57,53,55,57,59,0,50,0][0,59,0,0,57,0,0,55]
                record of a melody
                 • blocks in square brackets
                 • zeros are empty notes
                 • non-zeros are MIDI pitches
```

B Study 1 materials

The study was approved by the OU HREC with reference number 65064.

B.1. Software

The software developed for Study 1 is available at the following URL.

- https://github.com/morpheu5/SecondStudy-touch

B.2. Forms

The following pages present:

- Consent form
- Demographics questionnaire
- Music analysis worksheet
- Painting analysis worksheet
- Feedback questionnaire.

Learning music with musical tabletops (pt. 1)

Consent Form

The aim of this experiment is to collect, from each participant, the interactions with a tangible musical tabletop interface. Video footage will be taken during the experiment and used for further analysis. A small amount of additional information is also requested: musical experience, general comments.

The data will be made anonymous before it is made publicly available. All data are treated as confidential, and in compliance with the Data Protection and Freedom of Information Acts.

The experiment is estimated to take approximately 45 minutes.

You have the opportunity to withdraw from the experiment at any time with no adverse consequence.

You have the opportunity to have any supplied data destroyed on request, up to the point of anonymisation.

Still images and/or video footage taken during the experiment can be used in publications and presentations, with prior consent of the participant if the person is recognizable.

There are no risks associated with this experiment.

The results of the experiment will be used in my PhD thesis and in future publications. If you wish, I will be happy to inform you of any such publication when it occurs.

If you have any concerns or difficulties you may contact:

Andrea Franceschini (Main researcher)	andrea.franceschini@open.ac.uk	07549 115641
Robin Laney (Supervisor)	robin.laney@open.ac.uk	
Chris Dobbyn (Supervisor)	chris.dobbyn@open.ac.uk	

This project has been approved by the OU’s Human Research Ethics Committee.

I, ____ (print name) confirm that I have understood the above information and that I consent to participate in this experiment.

Signed: ____________________________ Date: __________

Please answer the following questions about your **musical experience**.

1. Have you studied music?
   - ▫ I have never studied music formally or informally
   - ▫ I received informal music education or I am self-taught
   - ▫ I received formal music education
     - If you have, for how long? ________ years
2. Do you play a musical instrument?
   - ▫ I play no musical instrument
   - ▫ I play one musical instrument
   - ▫ I play more than one musical instrument
     - If you do, how would you rate your skills from minimum 1 to maximum 5? ________ (considering your best instrument)
3. **(optional)** If you have studied music and/or played a musical instrument, at what age did you start? ________
4. Have you ever composed original music?
   - ▫ I have never composed original music
   - ▫ I have composed original music once or twice
   - ▫ I have composed original music more than a few times
     - How confident are you in your ability to compose original music? (1-5) ________

You will now listen to three short melodies. Please answer the following questions.

5. How many sections would you identify in these melodies?

   Melody 1: ________ Melody 2: ________ Melody 3: ________

6. How would you describe the “movement” of the melody in each separate section?

Section	Melody 1	Melody 2	Melody 3

Now please look at the picture and answer the following questions. Please answer in your own way, regardless of what you may already know about the picture or its author.

1. Describe what you see in the picture. For example you can follow these suggestions:
   - What forms do you see?
   - What colours do you see?
   - How are the represented objects organised in space?

2. Describe your opinion on the picture. For example you can follow these suggestions:
   - Do you think that the picture represents something? If so, what do you think is it?
   - Do you think that the colours give a particular mood to the picture? If so, what do you think is it?
   - Do you think that the author wanted to communicate a message? If so, what do you think is it?

5. Rate the following statements depending on whether you **strongly disagree (1)** or **strongly agree (5)** with them.

	1	2	3	4	5
I felt that accomplishing the music making task was difficult					
I enjoyed making music					
I concentrated intensely on the task					
I am confident in my ability to make original music					
I think that I will make original music in the future					

I felt like I was

improvising / live performing						composing

C Study 2 materials

The study was approved by the OU HREC with reference number HREC/2014/1797/Franceschini/1.

C.1. Software

The software developed for Study 2 is available at the following URL.

- https://github.com/morpheu5/ThirdStudy

C.2. Forms

The following pages present:

- Consent form
- Demographics questionnaire
- Feedback questionnaire.

Learning music with musical tabletops (pt. 2)

Consent Form

The aim of this experiment is to collect, from each participant, the interactions with a tangible musical tabletop interface. Video footage will be taken during the experiment and used for further analysis. A small amount of additional information is also requested: musical experience, general comments.

The data will be anonymised within five working days form the date of recording. You have the opportunity to have any supplied data destroyed on request, up to the point of anonymisation. All data are treated as confidential, and in compliance with the Data Protection and Freedom of Information Acts.

The experiment is estimated to take approximately 45 minutes. If at any time you feel uncomfortable with the experiment, you have the opportunity to withdraw from the experiment with no adverse consequences.

Still images and/or video footage taken during the experiment can be used in publications and presentations. If identifying marks will prove unfeasible to mask or remove, you will be contacted again and asked for further consent, which you are free to give or deny.

For this experiment you will be using electrical and acoustic equipment (computers, touch-screen, loud speakers). Precautions will be taken to minimise risks associated with such equipment. If you need any information regarding safety procedures, please ask.

The results of the experiment will be used in my PhD thesis and in future publications. If you wish, I will be happy to inform you of any such publication when it occurs.

If you have any concerns or difficulties you may contact:

Andrea Franceschini (Main researcher)	andrea.franceschini@open.ac.uk	07549 115641
Robin Laney (Supervisor)	robin.laney@open.ac.uk	
Chris Dobbyn (Supervisor)	chris.dobbyn@open.ac.uk	

This project has been approved by the OU's Human Research Ethics Committee.

I, ______________________________________ (print name) confirm that I have understood the above information and that I consent to participate in this experiment.

Signed: ____________________________ Date: __________

Please answer the following questions about your **musical experience**.

1. Have you studied music?

   ☐ I have never studied music formally or informally

   ☐ I received informal music education or I am self-taught

   ☐ I received formal music education

   - **If you have**, for how long? ________ years

2. Do you play a musical instrument?

   ☐ I play no musical instrument

   ☐ I play one musical instrument

   ☐ I play more than one musical instrument

   - **If you do**, how would you rate your skills from minimum 1 to maximum 5? ________ (consider your best instrument)

3. Have you ever composed original music?

   ☐ I have never composed original music

   ☐ I have composed original music once or twice

   ☐ I have composed original music more than a few times

   - How confident are you in your ability to compose original music? (1-5) ________

Rate the following statements depending on whether you **strongly disagree (1)** or **strongly agree (5)** with them.

	1	**2**	**3**	**4**	**5**
I felt that accomplishing the task was difficult					
I enjoyed composing a piece of music					
I concentrated intensely on the task					
I am confident in my ability to compose original music					
I think that I will compose original music in the future					

C.3. Initial discussion on similarity and contrast

The following pages present the annotations made by the researcher during the initial discussion with each participant.

Participant 01

- **participant is a designer**
- shape, size, colour
- chairs: "*you sit on all three, but for different reasons, and surely a throne looks grander than a stool!*"
- tea vs coffee: caffeinated, hot liquids, easy to make, same intent
- contrast: opposite colours
- JLB vs WH: JLB is modern, light; WH has another purpose, not offices
- *[relatedness]*: "*yes, I agree, you can't tell there is contrast if you can't compare them*"
- *[elephants]*: "*they carry people, but between a car and a van I don't know which is most similar to an elephant*"

Participant 02

- look, grouping
- "*similarity is when two things look identical... or similar*"
- chair: "*that chair looks more comfortable than this*", "*that *[frame]* is made of metal, this is made of wood, it's more classic, warmer"*
- "*take bottle openers: you get the same result, for different drinks, but with different mechanics*"
- contrast: opposite, not just different
- *[relatedness]*: "*I suppose that's true, I never thought of it that way*"
- *[elephants]*: "*A van is more similar... it carries people and it's big*"

Participant 03

- shape and colour are more relevant than function
- day, night; light, dark; warm, cold; city, contryside
- chairs: "*that one looks comfier, it's warmer, even though they are kind of very similar*"
- *[elephants]*: "*I can agree on that respect *[carrying people]*, but no, a van is a car, an elephant is an animal"*

Participant 04

- rhythm, scale, dynamics
- "*means or creates structure*"
- "*same mood, same tone, same intensity*"
- *[relatedness]*: "*Uhm, I think it's possible. I find it hard to imagine an example, but I think it can be.*"
- *[elephants]*: "*Probably more similar to a horse, though.*"

Participant 05

- **electronic musician, drummer when younger**
- rhythm, pitch
- colour, shape, complexity
- "*contrast is difference in an extreme way*", opposite, "*black and white, it's clashing, but they're still colours, right?*" *[relatedness]*
- chairs: "*yeah, I mean, a throne is so extremely different from a stool, I'd say they contrast. They're still chairs, though*"
- *[elephants]*: "*If you think like that *[comparing individual dimensions]* then you can compare everything on one particular aspect. It's like comparing elephants and tennis balls, it makes no sense"*

Participant 06

- similarity: it’s 100% identical, it’s the same", look 90%, function 10%
- contrast: opposites, 100% difference, black/white
- chairs: "*an office chair is more comfortable than both a throne and a stool: on a throne you are a ruler, you have responsibilities; on a stool you sit on a hard, flat slab, probably milking cows?*"
- *[relatedness]*: "*Yes! I couldn't have said it better! Thank you!*"
- *[elephants]*: "*I would say an elephant contrasts with a car, not sure it's similar*"

Participant 07

- similarity: "*it means having common grounds, the same language, ideas, perception, similar direction, perspective, overlap*"
- contrast: clash, opposites, "*antithesis*", "*not sure similarity and contrast are opposites*"
- function
- chairs: "*ultimately, they are all for sitting*"
- *[elephants]*: "*you can sit ON an elephant and IN a car... no, you can sit ON a car as well, but that wouldn't be too practical, would it?*"

Participant 08

- same function, situation
- opposites: colours
- perceivable features
- *[relatedness]*: "*Ah. I can't think of a counterexample to prove you wrong. I think I have to agree.*"
- chairs: "*Good example: I wouldn't say a throne contrasts with a banana tree, but it does with a stool, right?*"
- *[elephants]*: "*oh yes, elephants have been used as transport for centuries, haven't they? They are similar, just in their historical context.*"

Participant 09

- attributes, properties
- behaviour, function
- location in code
- "*laptops and desktops, they are different both have the same function, they are similar in that*"
- chairs: "*Oh, yeah, I coded on a stool, but never on a throne... I don't think I would want to do that*"
- *[relatedness]*: "*Ah, that's an interesting idea. I think so.*"
- *[elephants]*: "*I would say more like a van than a car*"

Participant 10

- repetition of patterns makes you recognise stuff
- chairs: "*Well, you sit on them, alright, but I don't suppose for the same reasons... you wouldn't milk a cow while sitting on a throne. You could, but...*"
- function
- contrast: totally different, opposite
- *[relatedness]*: "*Yeah, I mean, totally different, but not like elephants and tennis balls, right? More like elephants and mice.*"
- *[elephants]*: "*They have more that can be compared than just a tennis ball. In that sense, they are more similar than contrasting*"

Participant 11

- looks, function
- *"not totally different, there has to be a connection"*
- chairs: *"In some offices, they work on stools, so they kind of are the same thing to me"*
- *[elephants]*: *"A van carries more people, a car sounds more like it"*

Participant 12

- similarity: looks, feeling, features of a concept, function, purpose
- chairs: *"You can't compare those three, can you? Actually, you can: they have legs, and seats"*
- contrast: *"striking difference, like opposites, but also two things have to be comparable in some ways"*
- *[elephants]*: *"I think you can compare them, it depends on what: people carried? Free will? The outcome is different."*

Participant 13

- **writer**
- words with related meanings, or sounds, or strings of letters
- lies, *"lies are a politicians' stock-in-trade"*
- contrast: *"opposites, in meaning, which means they have a relationship"*
- chairs: *"A throne? Ah, I don't discuss thrones... but yes, I suppose the three are all chairs, in the end"*
- *[elephants]*: *"oh, with mice there's much contrast *[laughs]* but they are both animals... but with cars, they aren't, but both carry people and stuff"**

Participant 14

- form, shape, colour, taste, perceivable features
- physical properties of materials
- chairs: *"I wouldn't sit on that *[metal chair]* for my daily work"**
- function, appearance, style
- contrast: *"It's a comparable difference"*

Participant 15

- shape, outline
- different levels of detail give different types of similarity
- I start from the large scale, then use context and structure
- contrast: sheer difference, but in categories, features
- chairs: *"Those have four legs, that has a base, and it rotates, and the textures and materials are all different, but they're all chairs"*
- *[elephants]*: *"there's contrast in their... materials, but similarity in their function"*

Participant 16

- similar means the same genre, sounds, timbre, qualities
- visually, but also in function
- contrast: *"so different, with some similar bits, otherwise they are just different"*
- *[elephants]*: agrees

Participant 17

- similarity: same properties, patterns, rhythm, tonality, function
- contrast: opposites
- chairs: *"they all look like chairs, but the materials and shapes are different, and also the level of comfort"*
- *[relatedness]*: *"Not sure. It makes sense, I agree. I need time to think about it."*
- *[elephants]*: agrees

Participant 18

- similarity: *"function counts, that's important, then how you experience things, and tiny details"*
- contrast: *"it means mostly opposites, not totally"*
- chairs: *"I guess I'd rather not sit on a stool, that's the contrast for me"*
- *[elephants]*: *"The van and the car are still more similar to one another than to an elephant, but I see your points"*

Participant 19

- similarity: sound: pitch, length; technology: techniques to make, energy storage and conversion; dimensions, colour, shape, texture, mass, density
- purpose, function, use
- contrast: *"it doesn't mean opposite, it means there's a gap, a missing something"*
- *[elephants]*: *"In the context of transportation... but in the context of zoology, cars don't even exist"*

Participant 20

- similarity: style, pace (videogames), uniqueness, purpose, effects *[function]*
- contrast: *"it's something that surprises you, that takes you off-guard"*
- *[relatedness]*: *"Yes, in fact, how can you be surprised if you had no expectations of how it would be?"*
- *[elephants]*: *"Here, I was not expecting you to ask me this comparison. I see your point, though. In that sense, they contrast because one is alive, the other isn't"*

Participant 21

- contrast: different
- similar: *[not the same]*
- function, relation between features, no contrast without relation
- *[elephants]*: *"One breathes, the other doesn't... I think I can agree, but I'm confused"*

Participant 22

- *"some aspects can vary, but most have to be the same"*
- function: *"if you can use them for the same thing, they are similar"*
- contrast: *"it comes from comparisons, if you can't make a comparison, you can't say there's contrast"*
- chairs: *"I don't see big contrasts. Well, a throne looks nicer, probably?"*
- *[elephants]*: agrees

Participant 23

- chords, rhythm, tastes, background, outlook
- different, cold-warm, sweet-sour *[relatedness]*
- contrast: *[not the same]*
- different function
- *[elephants]*: "*more with a van, but I don't really see contrast in this aspect. One is an animal, though.*"

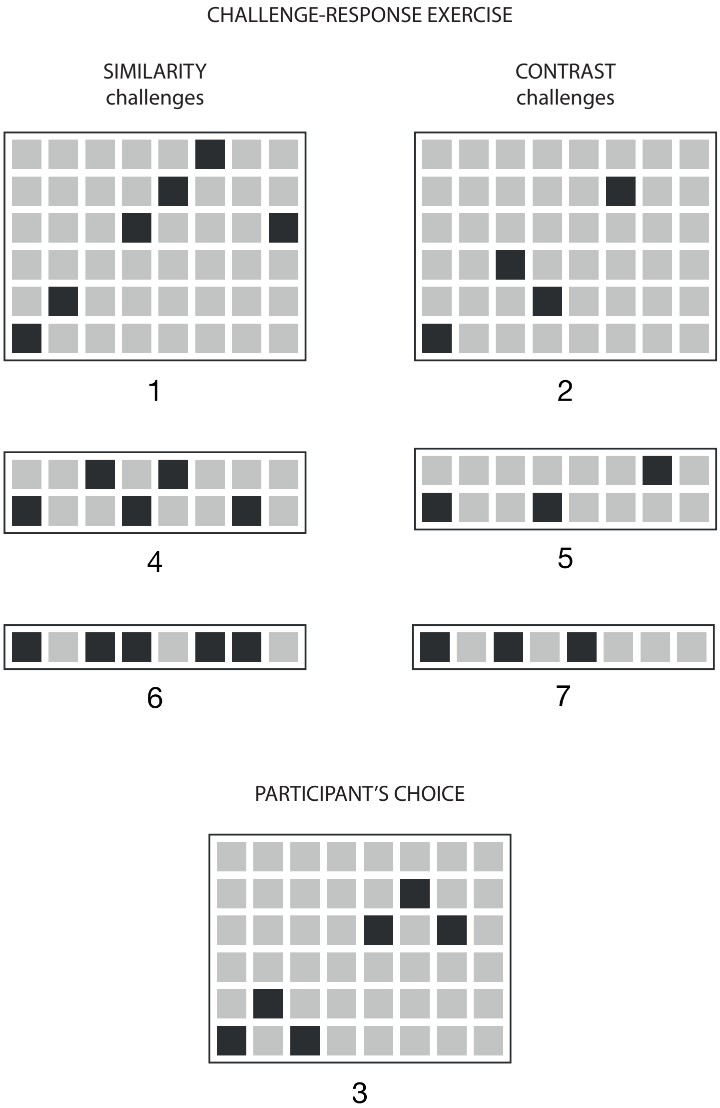
Participant 24

- one or more identical or nearby features
- purpose
- "*contrast means not just dissimilarity; there's oppositness*"
- "*there may be similar aspects, but striking difference in certain aspects*"
- *[elephants]*: "*They all carry people, but two of them aren't alive*"

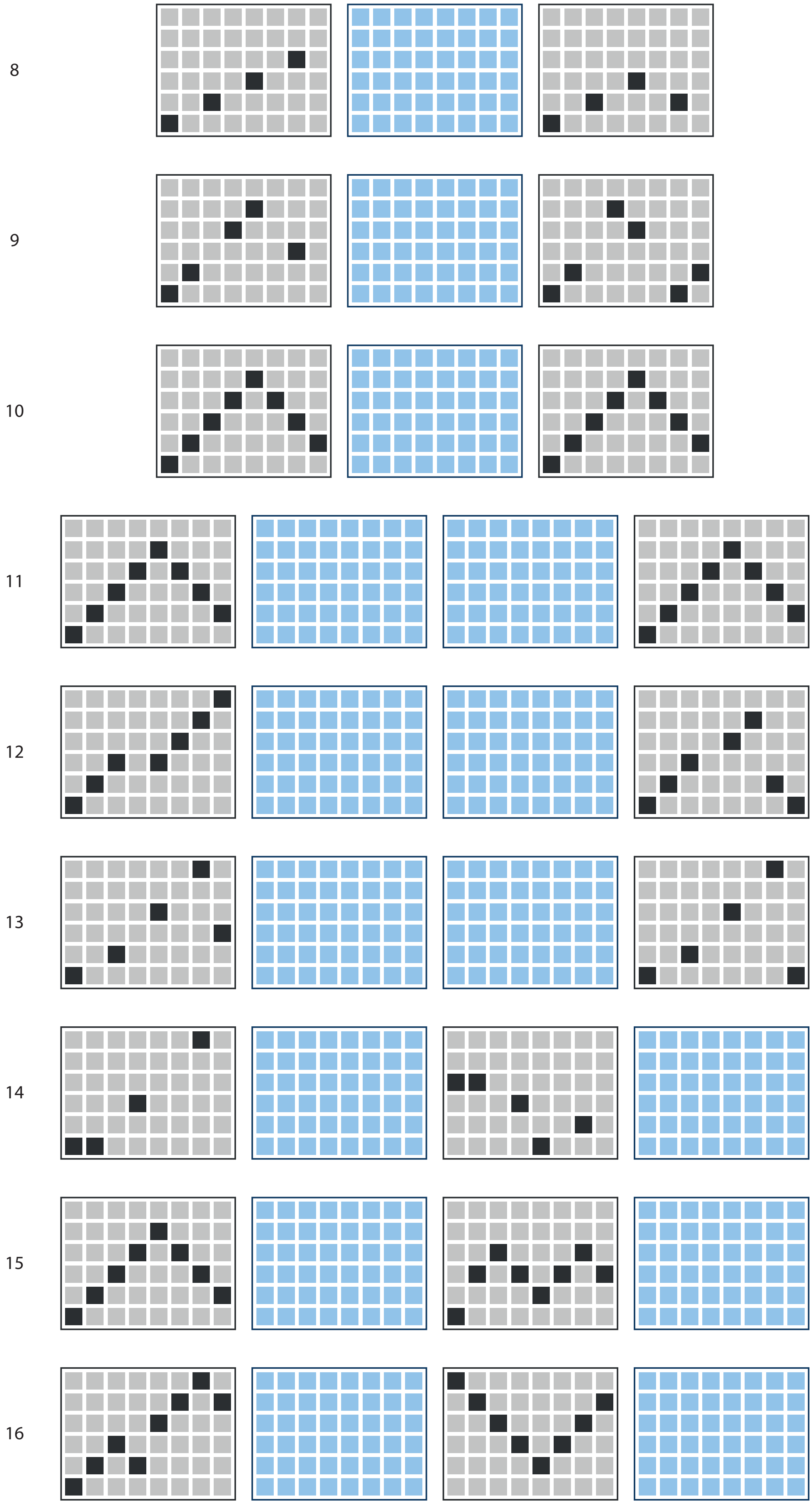
C.4. Music composition exercises

The following materials are included in the following pages.

- Challenges from the challenge-response exercise
- Presentations from the fill-the-gaps exercise



FILL-THE-GAPS exercise



D Study 3 materials

The study was approved by the OU HREC with reference number HREC/2014/1867/Franceschini/1.

D.1. Software

The software developed for Study 3 is available at the following URL.

- https://github.com/morpheu5/FourthStudy

D.2. Forms

The following pages present:

- Consent form
- Demographics questionnaire
- Feedback questionnaire

Learning music with musical tabletops (pt. 3)

Consent Form

The aim of this experiment is to collect, from each participant, the interactions with a tangible musical tabletop interface. Video footage, focusing on the interactive surface, will be taken during the experiment and used for further analysis. Please be aware that your hands will be in the picture, so, in the interest of anonymity, it would be best if you could minimise identifying marks such as watches, bracelets, and sleeves. The application that you will be using records, in form of log files, all actions performed on the surface, as well as the music produced. Such log files are inherently anonymous, and no action will be taken by the researchers to compromise such anonymity (for example by pairing them with video footage to identify who performed what actions). Video footage will be scanned for identifying marks and these will be appropriately masked, as they are not necessary for analysis. A small amount of additional information is also requested via anonymous questionnaires.

The data will be anonymised within five working days form the date of recording. You have the opportunity to have any supplied data destroyed on request, up to the point of anonymisation. All data are treated as confidential, and in compliance with the Data Protection and Freedom of Information Acts.

The session is estimated to take approximately 45 minutes. If at any time you feel uncomfortable with the experiment, you have the opportunity to withdraw from the experiment with no adverse consequences.

Still images and/or video footage taken during the experiment can be used in publications and presentations. If identifying marks will prove unfeasible to mask or remove, you will be contacted again and asked for further consent, which you are free to give or deny.

For this experiment you will be using electrical and acoustic equipment (computers, touch-screen, loud speakers). Precautions will be taken to minimise risks associated with such equipment. If you need any information regarding safety procedures, please ask.

The results of the experiment will be used in my PhD thesis and in future publications. If you wish, I will be happy to inform you of any such publication when it occurs.

If you have any concerns or difficulties you may contact:

Andrea Franceschini (Main researcher)	andrea.franceschini@open.ac.uk	07549 115641
Robin Laney (Supervisor)	robin.laney@open.ac.uk	
Chris Dobbyn (Supervisor)	chris.dobbyn@open.ac.uk	

The OU's Human Research Ethics Committee has approved this project.

I, ____ (print name) confirm that I have understood the above information and that I consent to participate in this experiment.

Signed: ____ Date: _________________________

Please answer the following questions regarding you **musical experience**.

1. Have you studied music?

   ☐ I have never studied music formally or informally
   ☐ I received informal music education (e.g. from a friend…) or I am self-taught
   ☐ I received formal music education (e.g. private music tuition, music school)

1.1 **If you have** studied music, for how long? _________ years

2. Do you play a musical instrument?

   ☐ I play no musical instrument
   ☐ I play one musical instrument
   ☐ I play more than one musical instrument

2.1 **If you play one or more musical instruments**, how would you rate your skills? (consider your best instrument if you play more than one)

bad						good

3. Have you ever composed original music?

   ☐ I have never composed original music
   ☐ I have composed original music once or twice
   ☐ I have composed original music more than a few times

3.1 How confident are you in your ability to compose original music?

not at all						a lot

Please indicate how much you **agree** or **disagree** with the following statements.
You can also add comments for each statement, if you feel you need to clarify your answer.

SD: Strongly **D**isagree **D: D**isagree **N: N**eutral **A: A**gree **SA: S**trongly **A**gree

	SD	D	N	A	SA
I am satisfied with the discussion					
The discussion helped me understand similarity and contrast in music					
The group work helped me understand how structure in music can be achieved through similarity and contrast					
The final result is a nice piece of music					
The final result makes a good use of similarity and contrast					
The final result is original					
I enjoyed discussing music with a group of people					

I am satisfied with the discussion
Comments:

The discussion helped me understand similarity and contrast in music
Comments:

The group work helped me understand how structure in music can be achieved through similarity and contrast
Comments:

The final result is a nice piece of music
Comments:

The final result makes a good use of similarity and contrast
Comments:

The final result is original
Comments:

I enjoyed discussing music with a group of people
Comments:

	SD	D	N	A	SA
The tabletop interface was a good medium for the explanation and discussion of musical ideas					

Comments:

I felt in control during the discussion					

Comments:

I felt in control during the composition task					

Comments:

I felt that I was able to undertake the final composition challenge					

Comments:

I felt that I could contribute to the collaboration					

Comments:

I felt comfortable contributing to the collaboration					

Comments:

I felt that I was contributing a lot to the group work					

Comments:

I felt that my contributions were appreciated by the group					

Comments:

	SD	D	N	A	SA
I feel that the final piece of music reflects the way in which the group worked					

Comments:

	SD	D	N	A	SA
I felt it was easy to communicate my ideas and intentions to the group					

Comments:

	SD	D	N	A	SA
I felt it was easy to discuss ideas and intentions with the group					

Comments:

	SD	D	N	A	SA
The interface was frustrating					

Comments:

	SD	D	N	A	SA
The interface was confusing					

Comments:

	SD	D	N	A	SA
The interface supported the discussion and group work					

Comments:

	SD	D	N	A	SA
The interface gave me clear feedback on what was happening at all times					

Comments:

	SD	D	N	A	SA
The interface made it easy to communicate my ideas and intentions to the group					

Comments:

	SD	D	N	A	SA
The interface made it easy to discuss ideas and intentions with the group					

Comments:

	SD	D	N	A	SA
I am confident in my ability to compose original music					

Comments:

	SD	D	N	A	SA
I will compose original music in the future					

Comments:

Any other comments?

If you participated in the previous individual session, which did you prefer? ☐ this ☐ previous

Why did you prefer it?

D.3. Transcripts

The following are the transcripts of the groups' discussions on similarity and contrast.

Group 01

1: I can't remember what I said the last time, I guess I said similarity is recurring after a state occurred on whatever you were looking at, and basically we're going to measure something, and that measure is the same across the experimential... but the way of measuring things can be different, it can be very precise or coarse, so it can take various forms.
3: The last time I said similarity is absolutely the same, both in function and form. About contrast, I think it should be 80-100% different! And also I talked about two things can be similar and contrasting, for example a different type of car have the same function but different appearance, like red colour and blue colour are contrasting in colour but they have the same function.
2: Similarity is something you can define mathematically, you can measure how different it is, you can just compare two things, decide how similar... contrast on the other hand is, when you put next to each other two things, how NOT similar they are, that's in a way... abstract.
1: It's kind of typical to say it depends on the object, of course, it's difficult to quantify, at some point you say two objects are different, but at what point do you say they contrast?

1: It depends on the actual melodies, sometimes it's the rhythm that is more important, sometimes it...
3: Based on the rhythm or on the level of the sound, because to me contrast is meaning how those two sounds differ.
2: Can you show me, to you, how two melodies are similar or identical?
1: [builds a pair] they are similar, but also contrasting in some sense, so I don't agree with you that they have to be 100% different but it's kind of difficult to find the exact spot when things are different or contrasting.
2: If I put these on a very higher pitch, and can I play both at the same time? [...] aaah, I'm doing something wrong!
1: I wouldn't say they are more dissimilar than before, even though the heart is different, you still have some similarity: whatever the amount of difference, it's still the same construction. [changes one to go downwards]
2: That's similar in the sense that it's one up one up one down one down
1: exactly, that's similarity in the construction
3: Do you think you have a relation between similarity and contrast?
1: I think, to have some contrast you need some similarity as well, that is: two things can be contrasting on one value but they need to be different on another.
2: I guess, if you want to put them in the same context...
1: Exactly, they need to be in the same context to be similar in some sense and to be contrasting in another, so it's kind of... [changes second]
2: No, that's definitely different
1: So for it's constructed... it's more different than the previous one?
2: [makes it regular] this thing would be more similar [reverts] this would be less
1: Yeah!
2: You expect 1 2 3 but this is a bit slower [irregular] and so you expect that...
3: It depend on the context of the music going up, but the pause, the length between the notes
1: In this case I kept the same notes, so it seems that rhythm is really important [changes dw]
2: No...
1: You really don't like that! [laughs]
2: I think the only similarity is that it's three notes [laughs]
1: It's still the same thing, because it's going down, but this would be different [makes a wide arc, related rhythm]

3: [changes 2] what do you think, that [2] contains the pattern [1]
1: Yeah... ah... mh...
2: It can be difficult to see.
1: In the end I think those are more different than those we did before, they are two different lengths, we're not comparing the same thing anymore.
3: Why don't we do [3-ramp vs 4-ramp] one is contained within the other, so the question is... we're not ranking similarity, but if we were playing the same as the last time, just provided these two and one that's the same but descending, which one is the odd one out? [makes a third with 3-ramp downwards] I would still pick this one out, it's not the same construction in length and...
2: It could be that [1] is similar to [2] and [1] is similar to [3] but [2] is not similar to [3]
3: What if you make them longer? Which one...?
1: Here you're changing all the lengths. I mean, the melody is not close here.

Group 02

1: I took a very open view about it, for example I said if there are two chairs, one two legs and another one four legs, there's both similarity because the purpose is the same, but then there's difference because one has...
3: but is that contrast or difference? Because difference is a soft thing for me, but contrast is a very strong thing... chairs with less legs are different, but a chair and a table are more...
1: So you mean contrast is a stronger... similarity is softer, I can agree with you. Similarity is soft but at the same time it's very hard hard, to make contrast as well
3: Yeah, exactly
1: You cannot for sure say contrast is always the strongest, it can be the softer.
3: Yeah, it is more difficult to me to discuss contrast, for example in the case of the chairs, the form is the same, the purpose is the same... so where is the contrast with chairs? This could be from a cultural perspective, the translation I make in my mind in greek... so what is the contrast to a chair, is it another chair with less legs, or different colours? To me it would be totally opposite...
1: But then it's not a chair! It's a different thing. If you're making similarity and contrast on a particular object, that is softer, but if you're comparing two objects, definitely stronger! Table, it's a different purpose, differen structure... you can't compare. That's why my idea is very soft
3: So for you both can be in this comparison
1: For me, how are you making the comparison? If same object, then it's soft, if another object, that's a different discussion. You can't compare a table with a chair.
2: Why can you not?
1: They are different objects for two different purposes
2: But you can sit on a table as well...
3: But that's not the purpose of the table, I guess.
1: Yes.
2: It depends...
3: It's like when you compare an apple with a banana...
2: They're both fruits
3: Yeah, but how can you compare the...
2: I suppose... I find it difficult to see something as totally opposite that has no similarity because I think there are all these differences in similarities, and similarities in differences, it depends on how you look at it, you can say you can't compare an apple and a banana I just thought, why can you not?
3: From my perspective, you cannot compare them because the outcome would not make sense
2: But why are you comparing them?
3: If the base of the comparison is not the same, how can you compare music with... image? You can compare two pieces of music and two images...
1: What she's saying, it makes sense to me as well, you say bananas and apples, for me they are different fruits, different nutrition, taste, colour: they are in the same category of fruit, but they are two different things.
3: But there are things you can always find similarities and differences in everything, but maybe I'm more influenced because of research, you can't compare different things in research because you're going to get wrong outcomes.
2: I find it interesting that you mentioned music and images, you know actually sound can create images as well...
3: Yeah, but how can you create something that is only in your mind?
2: That's not what I'm saying. Yesterday I watched a clip on YouTube and what they've done is they put a piece of paper on the speaker and some powder, and they play some sound, and the powder forms some images.

3: It's quite different from what I'm trying to say
2: It's a kind of image, though
3: No, but this is different. If I tell you something, if I put a song to you and then you see an image, it's two different things, it's not that the music is creating an image using different components like the video you're describing, it's just two different things
1: So one things is important, whenever you're comparing two things, you're not going to disturb the definition of the thing, for example sound: sound definition is, you hear it, you can't see it
2: That's one definition
1: For image, you can't hear the image, so that's my perspective
3: I'm saying that if they ask you to compare a photograph and a piece of music, the only comparison you can make is in the feeling they give you, but the actualy piece of the photograph and the actual piece of music... what kind of comparison can you make? The actual... physical thing, what you hear, that's my point. I agree that there are degrees of similarity, but how can you compare things that are fundamentally... ontologically different
1: Yeah, the thing is, there are rules of comparsion, and when you compare, you need to respect the protocol
3: or agree on... when you compare the apple and the banana, we need to agree that we compare them on the base that they are fruit, but you cannot compare them in the sense that one is round and the other... if you take a green apple and a red apple you can always say well these are green and red apples, but say this is a yellow banana and this is a red apple... what are you comparing?
2: But you can have a yellow apple and a yellow banana
3: Yeah, but I'm trying to say, what is the outcome of that? It's two things that are not the same, so I can compare them in terms of colour...
1: That's the thing, the definition, the protocol you define for your comparison, and what you want to get from your comparison, that sets how you compare things.
3: I would agree
2: Yes

3: The reason I find them similar is that because they follow the same structure
1: The structure is the same, the pitch is higher
3: So do you think contrast or similar...?
2: That tends to be my position because you can't really say either, you can tell both
3: So do we say similar because they are ascending or descending in the same way, or do we say contrast because they both...
2: Why can't we have both?
3: Yeah, if we say different, they are similar in terms of this and contrast in terms of that
2: Yeah, we can point out similarity and contrast, but we don't have to choose...
1: There are two different contexts and we have to decide on those bases
3: Let's try another thing. If I create the music following the same structure, let's say that, but I will start doing the exactly opposite thing, so...
2: That's actually not similar
3: To me it's similar because I followed the same pattern, and the contrast is because it's upside down
1: But in terms of sound it's the same
3: Because the structure is the same
1: Yeah, you can say that. So in terms of creation of the sound, there's contrast, but in terms of sound there is similarity
3: Exactly
2: I don't mean to keep disagreeing but the pitches are actually similar as well

3: Yeah, I'm just saying that where this is high, this is low
2: That's different patterns, but the pitches are the same
3: So if I do this, they sound... but the structure is the same
2: Actually I find the language difficult
3: Because I'm not a musician either
2: Not the musical language, it's when we say "the same" they're not the same, though
3: "Similar", it's not the same as "the same", it's different
2: I think we misuse the language, maybe...
1: So I think these are two different words, "similar" and "the same"
3: Yeah but similar is closer than same
2: "Same" is identical, isn't it? That's how I tend to think...
1: So how do you define "similar"?
2: "Similar", they can be similar in many different ways, like this one they are similar in that it's basically two notes being playied repeatedly
3: Yes, but the structure is the same, that was my rationale
1: So we can try a different structure and see
3: So are they similar or contrasting?
1: I think they are contrasting in terms of structure and sound
3: And as we said before, can you compare them?
2: I think they are certainly different, but wouldn't say they are contrasting, let's hear them again
3: It depends on how you define them, I define contrast as opposites
2: I tend to be more comfortable with similarity
3: Yeah, because contrast for me is stronger, it's the absolute opposite of something
2: So what do you think of this? I want to delete these all so it's completely silent
1: But then you can't compare them
3: Because it's silence, not music
2: It's interesting you say that because I think silence is part of music as well
3: I agree, but what is in between?
2: This to me is contrast
3: Because one is silence, the other is music, so it is contrast
2: Yeah
3: I agree with that, but that's the real contrast, because there are no similarities
1: For me it's, how can you compare these two things?
3: They are the two opposites, the light is the opposite of dark, music is opposite of silence, that's what I define as contrast
1: For me, the comparison, they are two different things
3: Imagine colours, a palette, they are colours, you have the in betweens, same with sound, sound and no sound are the opposites, light and dark, that's contrast for me, it's sooo strong
2: I agree with that
1: For me it's the object, I'm thinking in terms of you can only compare the things only if...
2: Do you think they share similarity in that they are two extremes
3: Yeah, you can say that, it's a good point
2: Black and white, they contrast, but...
3: You compare the excess, they both sit at the ends of the measurement

Group 03

1: I have some ideas about similarities and differences
3: I remember too much of what I said the first time so I don't want to repeat
1: First of all, anything visual or musical, I think there's first about distinguishing different sorts of object, and an object doesn't necessarily have to be a table of its own, a table also consists of different objects. And sometimes you can see and object in two ways, you enter in what is called dimension.
3: So how does that relate in music?
1: Oh, in music you have similar examples, where you can hear a melody, and when you slightly put the accent elsewhere you start hearing two melodies
3: That depends on where you focus your ears
1: Exactly, yes. I think it's a good starting point, because there are in between a number of these kinds of objects.
2: Recently I was listening to a workshop about acousmatic composition, and the lady was explaining about creating sound with your mouth, and so thinking about musical objects with the mouths. So maybe that's a way to start thinking how you create the sound.
3: So thinking about how you replicate sounds with your voice
2: Thinking about these descriptions can help us. So similarity can be for instance a complex sound which has variations, very much, compared to a sound that is kind of…
1: Yeah, but where is the link with the voice?
2: It's just a metaphor
1: I can write something down
3: Let's start thinking about simple words then. Both of them relate to your perception.
1: Perception is not only receiving but also interpreting. I think perception implies distinguishing objects. [writes]
3: Interpretation as well.
1: Yeah, this involves interpretation, you can say that [writes] and the output of all this is that… temporal spectral objects, in case of sound
3: You mean temporal like time and space?
1: Spectral is like spectrum of sound
2: Can you say something about the properties of music, like harmony, rhythm…?
1: It's maybe true that… harmony is of course part of the spectral properties, but I think an object doesn't have to be defined just in spectrum and time.
3: Are there similarities and differences in the spectrum?
1: We are trained to recognise objects in nature, and sometimes you can record such a thing, and do a simple transformation, and the object disappears
3: Even with sound? Say you record bird sounds? And you take it back and slow it down, like crickets
1: Yeah, sounds completely different
3: Sounds like an angel, if you slow down crickets.
1: Yeeeeeah, interesting…? So that's a very distinct interpretation of differences, where differences for us are very different in case of for a computer, so that's like remapping. So that's why I'd like to avoid to say spectrum right away. It's too scientific.
2: We can be more specific, we can talk about examples, about contrast and similarities? So how would you describe similarity in music? Or contrast? For me, contrast is difference, while similarity is small variations.
1: They are just opposite concepts, right?
2: So in music, a big change would be a contrast, but where there is an evolving change…

1: Oh, yeah, like a time evolving change, maybe?
2: That would be more similar...?
1: Ah... good question... Ok, if you compare the case where something suddenly abruptly changes, we can mention examples of similarity.
3: What about time we understand, if you're doing something very very very slowly, you're doing it slowly and you are aware that something is changing, where if you do something quick
2: There's a surprise, where there is a big change
1: [writes] changes over time?
3: So if you're playing a synthesizer or an electronic note, you think it changes even if you don't hear it? That's my problem with that, because if you were to pluck a guitar string, the note would fade and die away. Oh, I don't know the vocabulary.

2: Shall we focus on similarities and contrast?
1: So, given these dimentions [time and pitch], you can have similar shapes, or rhythm wise you can have... similarity in that way
2: Shall we listen to it? [plays] A complete contrast would be... well, this is a contrast, because this part is kind of similar, but then it changes, the second matrix is kind of contrast
3: Can you get rid of that?
1: Maybe?
3: So what is the difference? I hear it and I'm trying to look at these colours.
2: So we can remove all these notes, you can change the pitch over time
3: We can colour all of them...
1: Yeah, that's very similar!
2: Sometimes similarity can be boring
3: Totally!
1: It's an interesting concept, you can also say that differences are boring, if you put something completely random, that's also boring
2: You can say perception... you can't understand something that is completely random.
3: This doesn't please my ear...
2: It pleases mine! [everybody laughs] This is a contrast! It depends on the personal taste, where you see contrast or similarity, and whether your expectations are satisfied or not.
1: Would there be a more objective way to say...

3: [brings up Depeche Mode's Just can't get enough]
1: Maybe we can use it as a starting point for our story?
2: Maybe we can discuss about electro pop music, algorithmic composition... [everybody is dubious] it's a different... genre...
1: Let's find something simple and try to...
3: X meets Y, and what happens?
2: So we need a third matrix to explain what happens?
1: We can say they didn't meet, or here they meet and they go away?
3: Like, strangers? Strangers in the night?
1: Strangers? In the night? Ok... If you want to fill this, we need to... yeah, there is some contrast or some similarity, in the story, for the moment...
3: So you need to make two characters different
1: Ah, but we can not have more boxes, right?

3: You could
2: We can have them sequentally
1: Wait, hold on, this may be interesting, there you can use a technique of… when you say this is X [does] and this is Y [does], you can actually hear them approaching… the technique I told before when you hear two distinct… and then you can make them approach
2: Oh, yeah, and then?
3: Sounds good to me
1: Or I don't know, first they're just there and then he's approaching
3: Has he got only one leg?
1: And so here he meets… so here they meet [plays] and then they meet
3: Ok, so, you got those footsteps and then they bump into each other or they meet, or whatever
1: Yeah, then you can make something up, what happens when they meet, or something?
3: Did you do this randomly?
1: More or less, I was thinking… it's not very convincing [plays]
3: That sounds like two pitch, like, one person
1: Yeah, I would have preferred…
3: If you want to get rid of that one you can do [disconnects] and we can link them together
1: Maybe I'll make the meeting part longer [does] oh, I made it longer whan it should…
2: Oooh! So the meeting point comes slower
1: [continues working, plays]
3: Can you slow it down?
1: [stops] I don't think so?
3: So if you had fewer, would it make a longer time between steps?
2: Perceptually yes, instead of pressing one after the other, you would just press the odds, say, or…
1: If you, sorry?
2: So, instead of pressing each of the rows, or columns, you would do just the odds, or the evens, so just one yes, one no, yes, no…
1: Yes
2: That would become perceptually…
1: Yes, each time your brain connects this with this and this with this, that's the idea, but maybe [plays] oh, I would say I'm convinced, you hear something approaching now. Ok, so now it's your turn!
2: Yeah
1: So they've met here
2: Maybe now they can just go away
3: But before they move away, don't we have to have an incident here? You know, before they separate
1: Yeah, let's say you do the incident and we'll move them away
2: Oooh, ok! [laughs]
3: Well, the incident would be over here
1: Here they just met
3: What if they're coming together, there has to be like a bumping into each other, or an incident here, and that the result of that is that they leave
1: Ok, if you want you can add at this
3: Me, I can't, but if you could do it, they meet, and then something happened, something big, contrast!
1: So, like, they bump
3: Yeah, but they bump spectacularly…
1: Yeah! So explic-- yourself!

3: ... and then they go in the two directions! Can you do that? I get the idea but I don't know how to do it, so you can do that.
2: The idea is to experiment, isn't it?
3: Go on
2: How would you do that? How do you imagine that?
1: They separate so they go separate, like this
3: So here they're coming from two different directions, is it possible to having them starting in the same directions and moving apart?
1: Let's say that's maybe for the last part, where they're moving away, maybe we can say they're walking together, or someting, and you can do it just [does] something like
2: Maybe we can try what you were saying, rather than one
1: So here they're walking together
2: But then the idea is [does] one yes, one no
1: Ok, without
3: That's one space with one
2: Maybe that's different!
1: So maybe one person disappeared!
[all laugh]
3: Or one person picks the other one up
2: Maybe, yeah
1: Yeah, maybe. Let's have a listen to it [plays]
2: Maybe one goes here [does] and goes there, and they walk together!
1: Let's listen
3: It's too repetitive, we need to space for a kind of
2: Maybe this should be silent
3: Yes!
1: [plays, all listen]
2: Oh!
1: Yes, they met, they take the time... nice! Ok, so, last one? [makes new blocks] So now they disappear, they separate, so that's your part
2: You go!
3: No no no no...
2: So they separate, if they go together here, this is the starting point, and then one can go out, and then silence, while the other leaves away
1: Very... quickly. One goes out, actually. Ok, that's interesting!
3: That's a nice bit of humour
2: And that's how we do the coda, kind of the final... final final... final
1: I like this idea, because actually, perceptively you can understand this out of, sort of... so the whole thing [plays]
2: And maybe we need a final
3: A finale
2: A finale! You go with the finale!
3: That's good, we started with three, we ended up with four, we're quite good to leave with uncertainty
1: Ah, ok!
2: So, you go for that
3: [whispers] I have no idea [does]

1: We haven't so much discussed the similarities and differences, we just made the story and... although we used a bit of techniques, like the idea of splitting, having more different objects
3: [finishes, plays]
2: perfect!
3: So, once more from the very beginning [plays]
[all listen]
2: So these two are quite similar, this silence is kind of a surprise, and then there's this contrast, isn't it?
3: I have no idea here
2: And these two are like that, they kind of join to each other

Group 04

2: So, similarities, what do we think as being similar? How do you define similar?
3: You need aspects, things you can pick, if you choose to restict to music, something that sounds similar, the narrative...
1: But how can we evaluate something that is more or less similar? For me it's easier to compare two colours or two sounds.
3: But we don't perceive them in the same way, there's no way that we can say we perceive the same colour in the same way, we agree on it but...
2: It's a huge philosophical question
3: I agree! But for audio, it has to be the same, we can understand each others, I'm not talking a different language in you heads... I don't think.
2: But we're going away from the subject. In colour you can measure wavelengths, same thing in sound you can measure frequency
3: Sure, and interpretation of what music is... or how it sounds
1: But music is not only sound, there's probably some sort of emotion that makes that we don't compare logically two sounds
3: [long irrelevant digression on female vocalists and vinyl records] before I got a deeper knowledge of pop music, all female vocalists sounded the same to me, but now I can appreciate.
1: It's interesting how we compare these things, speed is one thing but I would say there's a core, something like a large orchestra or something very alone, like a guitar, I don't know what are the criteria behind that
3: So you say genre
2: Or if you establish that... how loud the sound is, what if they have the same tempo but different sound levels, are they similar? How do we categorise these?
3: [more on vinyls]
1: Even in the same genre, one music gives you a feeling, and another one gives you another, completely different feeling.
3: I don't know how you can differentiate
1: Probably different for every person
3: I'd love to get into classical music, but I can't differentiate between the different versions [recordings], how do you do that?
1: But from one to another orchestra, you don't perceive the same feeling
3: I can't!

1: One of the contrasts here is that it's constantly changing
2: Yes, but here instead... is this contrasting?
1: You're right, this is constantly changing, but for me it's not contrasting
3: Because it's uniformly changing, always going up and down. These have stuff in common, but I'm not sure what it is.
1: There's a difference... in changing the beat
3: It's definitely rhythm, and also reversed, this goes high.
1: You have silence [pauses] as well, here we don't.
2: Here you have similar groups [of notes]
3: The rhythm is the same, the structure of the change... if you change one of these so that it doesn't match that, in a way that's completely different [does] there's still a reversal in structure, they are still connected, they feel like they belong

1: Here I was trying to combine more amplitude with also silence, so... [plays] so it's also something different, there is silence, but all at the same place
3: Let's scramble them all completely [randomly].
1: It feels more like a typical melody because there's a bit of everything.
3: It's weird because for as random as this seems, it repeats, so it creates kind of a rhythm, it doesn't feel random anymore
2: So what if we just make... a huge random thing
3: And join them all, then
2: Why not?
1: I can't remember what was playing at the very beginning!
3: You have to make all on the same beat.

Group 05

1: The last time we talked about similarity on chairs, so maybe we can start with the chairs that we have
2: Ok? So there's similarity and contrast both in shape, colour, and material, or you can judge by the comfort you have while sitting
3: So there's comfort, I never thought of that
1: Me neither. When I was in my first session I was thinking more of the materials and colours and shapes. So I think we should see the difference between our three chairs. I can see you have two chairs that are the same, 100% similarity, so how do you see that [points] chair, the differences...
2: So this is an office chair, this is a lounge chair, the comfort is different. The office chair may also work for a student sitting at a table, the other is more relaxing, and also the material... this is wood.
1: I feel this is a warmer chair than that, seems "old" in a...
3: More formal
1: Yeah
2: The way you sit also influences the way you behave
3: I'd agree, if you look at the materials, this is wood, this is metal on the legs, and also different colours
2: And chairs are consistent with the purpose they were built for, so a lounge chair has better materials... they are coherent by themselves.
1: I can see there is a similarity in the upholstery, the seat, but not in the material of the legs, so if I have to think if similarity, there is but only in half.
3: I can think of chairs that are more comfortable, they might be more different, and that has wheels!
1: If I see the similarity between objects, I consider materials, shape, colour, but with ideas... it's not tangible!
3: I'd agree, it's more complex. An idea may be unique in itself, you'd have something to give it context.
1: Maybe if the field is the same, if you are thinking about two ideas on the same concept.
3: I know what you mean, if you look at a subject like science, that's quite broad...
1: For example music and science, probably there's a huge difference between the ideas of either field. Maybe it depends on the background of people, if you're a musician and a scientist, you can find relations between the two concepts, but...
2: I'm kind of lost, actually!
3: Objects are easier to say that's similar, that's different, you can see, you can visualise, what's the purpose? Whereas an idea, you'd have to know the ideas and all... so you can compare them to determine what the similarities and differences are. Does that make sense?!
2: So you say, if you have an object, you can have just one and apply your criteria to this object, while if you have an idea you need a list...
1: I agree.
2: Even though an idea depends on what you mean by that, because ideas and concepts are different things. So comfort may be a concept, you can have it quite clear.
3: Ok, you could... yeah...

[participants work for a while individually]
2: Ok, do you want to play and discuss them?
1: Yeah!
3: Ok!
1: Ok [plays]
2: What is it for you? Is it similarity or contrast?
1: I was thinking that there's similarity in the shape... no, in the patterns. But the sound... it seems like a

continuum
3: It sounds similar because it's doing the same thing, but it's going higher and higher and higher so yeah, it's got a similar sort of beat throughout each bar, there's no break, similar structure? But the difference, I suppose, the notes go higher and higher, it's not a big degree of difference [long pause] should we listen to yours?
2: Yeah, I've done something less focused on the melody [plays] ok, so what I thought is, we have some kind of melody pattern in this part because we have some intervals in the notes which are kind of classical, and on this side we have twice in frequency, the same notes with some contrast, in different octaves, and then also some differences in spacing, so three pauses and then a note, and then three notes and then... a bit of everything
1: So which is the degree of similarity and contrast
2: I think this is quite contrasting because of the melodic line is more... similar, but it's not... yeah.
3: I would say that there are some similarities in both of these two, in that you have got close notes going up in both of them, three notes going up, and there's similarity in the jumps, not the same distance but still... but then there's difference in that it's more uneven.
2: There's a difference between irregular and contrast. If you have irregularities, they don't respond to a pattern, while if you have contrast it means you have one thing and the opposite.
3: [plays] I was just trying to do one contrasting but with similarities, and one as similar as possible. In this, up and then down by one note in the scale, and this one is just one note all the way through... I could have just left it blank, actually.
1: I think the similarity is represented by this note [low C], but the whole patterns of the two squares is of course different. There is a contrast, but a similarity too.
2: Maybe if you had something more like [changes, plays] ok, no. But I was thinking of what you said, that you could have not put any notes in it and that's very interesting, so the fact that you put the notes is an additional similarity to me. Otherwise it's completely different.

1: We can think of two different characters, one opposite of the other
2: Or just one character, like Dr Jekyll and Mr Hyde
3: That's a very good idea!
2: Yes, because he has all this contrast within himself

Group 06

3: When I think about similarities, I think about Gestalt theories, are you familiar with those?
1: No
2: No
3: It's like a german guy who describes ways you can group things, and things that make them similar, he has different theories...
2: Size?
3: Yeah, size, and similar shape, colour, I feel like it's more general than we are saying.
1: Right, I guess the obvious way to evaluate is visual features, but also functional similarities, things can be visually distinct, like a spoon and a fork
3: There are things that have different... like two computer monitors who are both 19 inches and both have speakers on the bottom, and have the same resolution, they can be quite different base on how sleek they are.
1: Or things can look and function similarly but have different origins, I think we're all north americans but we all look different
3: Sometimes you can tell a person is British, or more accurately that they are not British.
1: But point being that you can have similar origin points and be different, like you can be perceived to be dissimilar. I don't know, baked goods can come out of the same oven, and made of the same components, flour and sugar, but look different on the tray
3: There are things who are combinations of other things, like sand or biscotti, if you crumble it down it would turn into a bunch of little crumbs, so it's kind of one object composed of a bunch of infinitely small objects.
1: Ok. Dissimilar things can be things that can feel different
3: So, the obvious critera would be shape, size, colour...
1: So, like, appearance, would we be able to consolidate those three into appearance?
2: I like appearance
1: If we discuss how those map onto [music] like size as length, breadth as scale... [pause] Function maybe a little? Like, is that a musical... music for enjoyment or a fire alarm? They are sounds for different purposes
3: Yeah
2: Totally
1: And the combination of instruments making a sound, versus a computer making a sound
3: I feel that another one that especially relates to music is how busy something is, so this screen doesn't have a lot going on, but the carpet has a lot of fibers, so it looks busy.

1: You can take this one, then.
3: So, this is my melody, so if we connect yours with mine, maybe you can try a contrast?
1: Do you see contrast as having no melody, or do you see it as a reflection, which in a way is kind of similar, like there's a relationship between...
3: I mean, there's different ways it can be similar or different. You can just go up and down, or you could have notes on every single grid point. Let me try another one. [makes] So, this one is sort of the second half of this melody in the sense that it contrasts, as it's going off the beat, and this is definitely on the beat [taps foot on the beat] so you could try something that could go in between?
1: Maybe just a blank bar like this?
3: I mean... ideally not!
1: It'd contrast with both!
3: What I found to help when you don't know what to do musically is to just put some points in there and then adjust them later

1: So kind of a mix of on and off the beat?
3: I'm saying just put anything in there.
1: Oh, that's not good
3: What if you tried using higher notes? Like if most of your notes were in the top of the score?
1: What feels good?
3: I think it sounds good to me. I don't want to be the one who says all the things
1: The more you listen, the more catchy it is... do you want to try to do this?
2: Sure!
3: Should we... can we pause?
1: Yes! [pauses]
3: And then work on that one.
2: [working]
3: It's almost Jurassic-Park-y
2: [working]
3: What if we double that?
[all working]
3: If we duplicate that?
2: [working] It doesn't like me!
3: I feel like it's becoming too complex, it's hard to remember anything because it's too...
1: Although this sounds great, it's beginning to sound like a '90s sit-com theme
---
2: Did we just lose all our work?
[r: yes, but I recorded it]
3: I wonder who owns it
[r: you do]
1: So when it shows up as the theme song for a Bulgarian sit-com...

Group 07

1: So, we're discussing contrast
2: Similarity and contrast
1: In general, not in the context of music
2: Ok [long pause] Well [pause] How do you describe similarity when [inaudible] they have things in common? I keep going in circles, they're similar because they're similar, they're similar because they're same in parts, I think my feeling has to do with what proportion of parts has to be same-ish, corresponding in some way, and what proportion can be not corresponding and it still looks similar
1: Right
2: And, by parts I'm thinking about things like structure, colour, size
1: Any kind of property
2: A significant part, there is some significant- defining characteristic, and some proportion of that characteristic have... likeness [laughs] how do you define likeness?
3: I think it depends also in the context, because for example, if we're talking about different types of transport, we can find that a bus is similar to a car, but if you're comparing the [inaudible], for example
2: But I think my point holds, because a bus is similar to a car because they're both wheeled vehicles that go on roads, but they're contrasting in one of the dimensions because one is meant as a carco vehicle that carries a lot of stuff, and in another dimension one consumes a lot of fuel, so I think the key- there's a sense of what the key characteristics are and how they are weighted that gives us a kind of way to assess similarity or contrast, and if I start thinking [inaudible], contrast depends on what's its purpose, because there's contrast in the sense that it has to be similar enough to make a comparison and then have something stand out, different, rather than they're so different as in different universes, and I'm not sure that that would be contrast anymore, that kinda excludes [gestures a big bubble] goes outside, I don't know, the whole proposition of contrast
1: Right, yeah
2: So, do we define similarity in terms of contrast, then? I mean, they're actually quite useful as a pair
1: Yeah, I mean, it seems like you kinda set your agenda by determining which dimensions are important for the type of similarity and contrast you're interested in and then you also have to determine some degree of nearness in those dimensions that counts as similar, like the car could be completely dissimilar to the bus if you're interested in cargo, or it could be similar in terms of size, or it could be dissimilar in terms of... another way
2: So when is a train more similar to a bus than it is to a car
1: Yeah, when you look at the amount of people they carry
2: So, it depends on what you're interested in. So, do we say that similarity and contrast are always specific to context?
1: I'd say so
2: Ok. The thing about contrast [pause] thinking about artistic works, contrast is almost a device for causing to reflect on similarity, or to reflect on the key characteristic, right? Contrast is a way of drawing attention to whatever the key characteristic is, or maybe to just draw attention to the thing- the entity [inaudible] that seems to me the really important way that it gets used, and certainly reasoning about ideas, contrast is used to clarify distinctions, to clarify what's important, and why. So, it can be useful, I guess that's what I'm saying, but what does it mean?
1: Yes, like a concept and a rant, like... do they contrast? Or
2: So, can we assess contrast if there's no basis of similarity?
1: You can probably always find one, like you can say the concept [inaudible] and you go on and make a dimension in which you compare things that don't seem to...
3: Do we understand contrast as opposite to similar or not? For me, they are not

1: They could be similar and contrasting
2: But I think that's why the notion that there aspects and dimensions of the characteristic that we're looking at, so contrast within a specific characteristics means difference but maybe sitting in a context of similarity in other characteristics. What I haven't got clear in my mind is whether it requires it to sit in a context of similarity in other characteristics, or the potential for similarity, if that makes sense. So yeah, I agree that they can be similar and contrasting, and I suspect that, for contrast to be effective, there has to be some balance between them
1: In, like, the dimensions that they share
2: I kinda feel like that, maybe we should think of examples to figure out if that's really true or you break it
1: I think if you can find two things that didn't have any compatible dimensions, they contrast in their lack of- there could still be a contrast, would they not?
2: But then it's rendered absurd, because it's too extreme, unless we have a setting in which, actually, we've been talking about insect behaviour in analogy for the generation of ideas, or the dissemination of ideas, in which case an ant is like an idea because then there are colonies of ideas, they relate to each others, and they spread into the ways- I would think that I would struggle to find a comparison -- oh, comparison, core idea! -- that would completely defeat us.
1: And you can quantify some aspects of those things, and contrast those like a [pause] you can quantify the amount of concepts in the world and the amount of ants and then contrast them on that scale, and you just create a context
2: So, a few things we seem to agree on: one is that similarity and contrast are interpreted within a context, and with their purpose; another thing is that they can coexist, this idea that you've recognised that there's more than one thing, and you're comparing them
3: And if you're not comparing
2: Entity. But the notion that you may be able to quantify is interesting, or at least you ultimately end up focussing- if you're making a judgement about similarity and contrast, you're focussing on key characteristics. That feels intuitively right, I'm not sure if it'd hold up
1: You kinda need a wider context to determine what is similar, like, if one thing is five and another is six, it's the wider context which will tell you whether you classify them as similar or contrasting
2: Yes, and what means similar in one contex may mean not similar in another, so we're deeply into context
---
2: We know that there are key characteristics. For me, there are parts of music that I respond to, there's melody, there's rhythm, there's tempo, there's the genre, a voice to it. So what makes something reggae instead of hip hop?
1: That's all cultural associations rather than, say, phenomena in the sound
2: Or both? It's the association of cultural association to a particular kind of sound?
3: And training, if you have some music training you may hear different things
2: I'm pretty sure that real musicians chunk up music differently than I would
3: I have a friend who is a musician, and he listens to a completely different thing
2: But what are the kind of things that I would pick up on? So, rhythm, hugely- hugely important to me to gauge similarity [pause] and melody: if I wanted to think about... So we're going to be asked to use music to tell a story, so what are the things that we vary to tell a story? Aaah, key, you know? The tones that you choose. So, my suspicion is: how many of these dimensions would have to be similar, as more like it in some likeness measure, for us to say two things are similar, and how many would have to be different for us to say there is contrast?
1: Musically?
2: Yeah
1: Again, that depends on your context, like you say oh, they're really contrasting in terms of rhythm, because there are slightly different rhythms that put in the context of, say, samba, they would be contrasting, or the

context of all possible arrangements of sounds
3: It's interesting because sometimes the same player plays in two different styles, they do sound different but you still recognise for example the melody, and the kind of thing is the same song, no? Or maybe they are really contrasted
2: And I can imagine how things that feel the same-ish emotionally, you can imagine lots of people making lullabies, but they have entirely different constructions in terms of melody- I suspect there are things in common, in terms of choices of notes, you wouldn't choose something jarring for a melody, for example
1: Yeah
2: I wonder, dance music. If the three of us sat down and categorised dance music, yes or no, something tells me we wouldn't choose all the same stuff
[discussion leader explains the interface to the others, they all mimick]
1: And this is structuring, I can link them and...
r: so, you--
2: Go away! Let us play! [laughs]
[15:10 17:50 -> 2'40'' all participants discuss various features of the interface and learn how to use it together]
2: So, contrast! Similarity!
1: I mean, we've got very specific dimensions. I mean, we've still got other dimensions like the [inaudible] we can't go out of the scale, and you can't deviate too much rhythmically, I mean, could you do something like imply kind of a reggae...
2: Well, you can do more than one not at a time
1: Yes
2: And you can, just, you know... so, one dimension is time and one dimension is notes on the scale, right? So...
1: Yes, these are kind of the obvious dimensions we have, like timing and pitch, but there's still the sort of cultural resonances in it, like if I tried to play Twinkle Twinkle or something like that, it would have a different dimension...
2: So why don't we, as a first step, construct something simple and then see if we can make something that is similar?
[they clean the board by moving blocks away]
1: We just do one block and then...
2: Yeah, yeah. [pause] Somebody jump in, or I'd do something... arbitrary.
1: This [composes] could be *a* thing, and it could be that this [draws the pitch-reverse] is contrasting, although it's pretty similar
2: Then why don't we play it?
[2 composes the pitch-reverse on another block, misses one note, 3 fixes it; they play them together]
1: It's kind of a continuous line
2: That was interesting [pause] that's not very contrasting, is it?
1: Well, it contrasts on one dimension, depends on who you analyse it: that's descending, that's ascending? So, completely contrasts on that dimension.
2: We should maybe orient these so we're standing all on the same side? 'cause I'm spatially challenged.
1: Yeah, do you want to come around this side?
[they re-orient the blocks and all stand on the same side of the table]
1: You can pick your dimension of similarity and you can pick your dimension of contrast
2: Let's try to do something that has kind of a melody to it, as opposed to just a... yeah? [composes, plays] that's pretty dumb, so, how would you make something that's similar to that?
1: Well, you could... depends on what dimensions you want to do
2: Do it! Just make something similar!

1: Ok [does, they play]
3: And something contrasting?
2: We could just [connects the two blocks, plays them in sequence] so that's pretty similar, they have an awful lot in common that's actually [inaudible] ok, so, contrasting.
3: Yeah, I can try [starts working]
2: Have a go, it'll be interesting to see what you go for first, what you vary...
3: I don't know, that's a bit similar... [connects the new one and the original one, disconnects the previous "similar" one]
2: Ok, I would suggest that those are still pretty similar
1: Yeah, it depends on your dimensions
2: So, what are the dimensions?! In what sense is it similar and in what sense is it contrasting? That's the key!
1: Right. It contrasts in terms of the relatioship between each and the subsequent... are kind of inverted
2: The rhythm is very similar
3: It's the same
2: You have that, and it's a very small range of notes
1: The dimension you seem to pick was the delta between note to note
2: So, if we wanted to make that more contrasting, how would we make it? Change more?
1: Can you think of the complete contrast of that?
2: That's an interesting question, it's not just inverting it.
1: No [composes a new block with just one note] There's a contrast
2: Ok...? I'll buy that...
3: I mean... maybe the contrast should have something in common, because if they don't have anything in common, it's just music... I mean, it's music both, but...
1: So you say there's a limit to contrast when you go beyond it... contrasting, it's just different
3: Probably
[2 works on the "one note" block and plays] Oh, sorry, there's no duration [repeated note of the same pitch]
1: No, it won't hold the note
2: I mean, that [modified "one note"] sounds more different than these two
3: Yes
1: You say, objectively more different form those two than they are from each other?
2: It sounds more different to me, no, I'm saying subjectively [long pause] and the ways in which it differs are not ways that express simmetry, so I'm wondering if you make two things different just by exploiting the symmetries and they stay more similar that if you made them different by just making them different in a way that doesn't have a kind of clearly mappable relationship. Does that make sense? So, this one was about inverting this one, but it kept the relationship between- it has the same shape, I don't know how to express that but that's the best way I can do it. But this second one the relatioship between the notes are different, and I'm wondering if simmetry lends itself, even though it's a contrast, a form of contrast, lends itself to a kind of structural similarity as well? Something that we're not necessarily picking up explicitly?
1: Right
2: I'm struggling to articulate
3: But the thing is, if they are not similar, even there's no simmetry or whatever, maybe there is no contrast, they are just different
2: So, can we do multiple notes? Sure we did...
1: If you have two running in parallel but it's quite tricky to set up
2: and make it run simultaneously, you kinda need to be able to
1: You'd have similarity on harmony, that kind of thing

2: So we have very few dimensions here to play with! That's what I'm rally saying, because the duration of the notes is the same
1: In terms of the actual settings, you can have things like- you might get to meaning similarity in the significance beyond
2: The question- we get to play with pauses, on-off, and we get to play with the choices within this very narrow spectrum [scale] and shapes, relatioships, relatedness and repetitions
1: But you can also play with, oh that's a recognisable tune, that's not a recognisable tune, or--
2: Ok, what if we cancel this - set it aside for the moment - and pick up the things that are- and program a recognisable tune?
[1 programs "Mary had a little lamb"]
2: And I though he was going to pick Ode to joy! So disappointing! [all laugh] well, do we all recognise it? So now we presumably need to pick another one and try the game again and see if we can make it- uhm- more or less similar!
1: It just seems involving picking a dimension that you feel like contrasting
2: Ok, so which dimension? Let's do it, let's go for it!
3: Rhythm? The more logical thing [one block, one note] this is completely- but I wouldn't say that this is contrast, I would say that this is different
1: I'd say you contrasted [pause] strong contrast
2: Because
1: You contrasted the rhythm quite carefully, the melody has something in common 'cause it contains the main note from the other one... I mean, it's contrast. I wouldn't say it's- especially when you consider they're both musical, that's a contrasting passage from the other one
2: So, if we actually play these together, I don't think it would sound bizarre
1: No, I don't think you could make anything that sounds bizarre
2: On this? Mmmh, I don't know, I wonder, but... do you see what I mean? Is that a measure of [laughs] I guess it'd be hard to make something clash as opposed to... so, that's contrast, how do we make something that's [pause] so what if we wanted to turn this into something similar? [composes] I don't know?
3: In terms of...? [plays it]
1: Yeah, it has similarity, but it has differences. To me it's like that's "Mary had a little lamb" and that I can't identify anything
2: It's interesting that you don't recognise that... and this either, but it doesn't intrude in the way that that does: it doesn't assert itself as a different melody, it sounds like accompanyment
1: Well... yeah
[3 stops]
2: Thank you
3: It sounds like a washing machine
2: [laughs] Ok, that was interesting. How can we do a contrast that is stronger but not pushed to absurd level? Where there's still melody but actually very different?
1: Contrasting with that again?
2: Yeah
1: Again, you can pick your dimensions
2: We have a couple
1: But I mean, beyond that, so that seems to take some sort of melodic shape whereas [composes a streak of one note throughout a block, plays]
2: Ok, has melody, doesn't have melody
1: Yeah, I mean...

2: So, if we step away from that extreme to "has a kind of melody or a bit of melody"
1: You could have continuous melody versus sort of very discontiuous melody [illustrates on the table]
2: Ok. See, for me that's a better- that's more contrasting in a sense: it's more meaningfully contrasting than just having
1: By the meaning you decided to attach to
2: Exactly [links these three examples in sequences and plays them] So one of the ways that I would think about that is, as a novice, those- if you said which part sticks out, that's the part that sticks out [very discontinuous] right? So, by the novice metric, that would seem to me to be ok. On the other hand, I just heard you go "hmmm" and I want to know why, 'cause that was actually intriguing, in a way
1: I feel like you could find more dimensions in which the middle one [very irregular] is different from the first and the third. I mean, they both have the same pattern of notes, they both have the same repeat threes, they start on the same note, and have almost the same range
2: This here has kinda the same shape, but in a different place, a different sound [pause] so is this more different than this or is that more different from that?
3: Say again, which...?
2: That, and this, form that one. This is our reference piece
3: I would say that this is more similar than this one
2: I would too. What do you [1] think?
1: Yeah, but again it depends on how you pick your dimensions, maybe
3: I think it's because of these notes here [repeated], but here [v.irr] you're not repeating any note
1: And it's a seven notes versus eight notes phrase
2: Ok, you can fix that. What if we make that one up here
1: Still a seven notes versus eight notes...
3: You have said they have a similar range, and they have a repetition...
2: ... and they all drop the last- yeah. So, range is an issue, the rhythm is the issue, I think this kind of repeated shape that comes up makes a difference, so here's a different question. So, if we take this one [v.irr] out of the mix so that we just hear these three, the question is, of these two, which of these is more differen? Because that's obviously the contrast one, that's a big contrasting one. [plays] That's contrasting [3] now.
1: Yeah, the whole second half of these is identical.
2: Well, we can... change that. [does] didn't make a significant difference
1: It makes them more similar
2: So, you're almost quantifying in terms of number of notes
1: That's one dimension you can look at, if they had identical notes, they would be the same
2: But that's boring
1: I always use that to test the limits of things
[they start missing the stop button so several blocks start playing at once]
2: Here's a serious question: what do you pull out of it? Is it just noise or do you end up finding things that you recognise an anchor to? [long pause] 'cause the repeated patterns seem to give it a real degree of similarity for me, I'm kind of making recognition to the noise. Cool.

1: That's quite a big task now
2: Oh, I went down to the grocery store, I couldn't find what I wanted, I went crazy, and then I went out of the store, and somebody's following me so I ran really fast until I got home and got on the door.
[they recap the story, write it down on the whiteboard]
[mostly utterances about details follow: "how do I?", "does that sound like that?", "I like it", "I don't like it", and so on]

Group 08

1: So, similarity and contrast?

2: In music or...

3: No, I think in general, like, what do we think two things are similar or contrasting...

2: Oh, ok

3: How do we go?

1: Shall we go around, say something each and then...

2: Yeah, let's do that

1: So, similarity. What's similar? Is it similar when they have the same shape? To me, that's the prime reason for...

3: Shape as in appearance

1: Right

3: So what about... say... boomerangs?

1: What about them?

3: Well, they all have different shapes, like curved, or those star shaped, you know? But if you throw them, they all come back, and people used them to hunt

2: I'd say all boomerangs are similar, because they come back and you can use them to hunt

1: Well, not all of them surely are for hunting... like the star ones, I don't think they were used for

2: Yeah, probably

3: So what do we say? Some boomerangs are more similar than others?

1: I guess...

2: You can say that not all of them are used for the same purpose, but they still come back if they don't hit anything, so that makes them all boomerangs

1: Yeah

3: Yeah... I suppose...

2: So, for example... let's take something else, I'm not too knowledgeable on boomerangs! Let's say...

1: Well, I'd say let's keep track of what we discuss, shall we? [grabs pen and paper] So... shape, function... what else?

2: I was gonna say that you can consider things similar even when they don't really look all that similar. Say cars and trucks...

1: Yeah

2: They both carry people, and stuff. They have similar functions, but hardly similar shapes.

1: They still have wheels, and seats, and pedals, and...

2: That's my point, they are similar, but different!

3: Ah...

1: In the sense that...

2: But... but then in size they may contrast, like a Smart versus a huge-ass multi-wheeler truck

3: Yeah

1: I suppose... but you wouldn't call contrasting a Smart and a whale

2: Eeehm... I suppose not... Well, why not?

1: They aren't even the same thing! One is an animal, the other a machine, they differ in size, they don't have the same function...

2: What about a truck and a whale, then?

1: Same deal! They may compare in size... well, I might say that their sizes are similar, but that's not enough for me to see a truck contrasting with a whale

2: Ok, so what about a whale and a codfi--no, a dolphin

1: Well, they are both mammals, they both swim, they are of different sizes, obviously... yeah, I think that could work for contrast
3: So ok, we have shape, and size, we have function, and we need to be able to compare things on some level
2: Yeah, not necessarily on all levels, otherwise they'd be too similar...
1: Ok, so I guess we have a bunch of criteria we can carry on, shall we move to music maybe?
2: Oh yeah!
3: Let's do it!

1: Ok, how does it work?
3: Hold on, I think I remember... if you do this [long tap] that pops up
2: Oooh, can I try? [does] Cool!
3: And then you can scribble [does] and...
1: Let me try! [does]
3: And then if you touch here [taps play] it plays!
2: And if I [touches play on another block] oh... [two playing together]
3: Yeah, that... so, if you draw a line like this... [does a connection gesture] you make it longer!
1: Cool!
2: That's very... funny!
3: And that's all I remember, really...
1: I guess we can work with that!
2: So, are we supposed to do the story--no, discussing similarity and contrast, but in music, right?
1: Yeah, so, how do we proceed?
3: I suppose...
2: I think we can each make up a few examples and discuss them, right?
1: That'd work
3: I agree
2: Who begins?
1: I'll go. So, if I make this... aaand... this. What do you guys...? Oh, I suppose to me they are very similar because they both have the same speed, and they go up, and down, and up...
2: Yeah, they look very similar to me... oops, I should have said sound!
3: So we have rhythm... and well, shapes, right?
1: Yeah, that was my idea... so, who's next?
3: Let me... [does] to me, these are very contrasting. As in, they have this and that in common, but they go their separate ways in the middle...
2: Yeah, no, I see your point, but they sound similar to me. Say I change this [does] oh, well [changes again] here, I suppose this to me is more like contrast
3: Ok, but where's your hook? How do you compare them? To me, these are just different.
1: Yeah, they are just apples and oranges--oh, no, those are fruits! [all laugh]
2: Still, there's a sense that they go... but in a similar way, do you see what I mean?
1: I... yeah...
2: Yeah, I see...
2: Ok, so let me try this instead [does] and how does that sound to you?
3: I'd say they are similar
2: That means I'm not very good, then...
1: I think I see... so, there's a need for two things to be... to have some relationship, right? But that can't be too close or they would be similar instead of contrasting. So where's the red line?!

2: Yes!
1: That's what we discussed earlier, right?
3: Ah, I see…
1: Ok, so we have shape, rhythm, and the need to be related, right?
3: But how do we use them?
1: Oh, well… we'll figure it out!
2: Yeah, I'd say we head to the story thing.
3: Agreed
1: Yeah, let's do that